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RECONNAISSANCE AND PRELIMINARY INTERPRETATION OF UPPER DEVONIAN TO PERMIAN STRATIGRAPHY OF NORTHEASTERN ELLESMERE ISLAND, CANADIAN ARCTIC ARCHIPELAGO

U. Mayr

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View eastward, toward the upper part of de Vries Glacier and the main ice cap of northern Ellesmere Island

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RECONNAISSANCE AND PRELIMINARY INTERPRETATION OF UPPER DEVONIAN TO PERMIAN STRATIGRAPHY OF NORTHEASTERN ELLESMERE ISLAND, CANADIAN ARCTIC ARCHIPELAGO

Abstract

The northeastern extremity of Sverdrup Basin, which includes a conformable succession of rocks ranging from Early Carboniferous to early Tertiary, is exposed in northeastern Ellesmere Island. There the basin is underlain by a complex basement sequence that was last folded during Late Silurian–Early Devonian and, locally, by Upper Devonian nonmarine sandstone and conglomerate of the Okse Bay Formation.

The oldest unit of the Sverdrup Basin is the Lower Carboniferous Emma Fiord Formation, which is present along the basin axis and consists of nonmarine conglomerate and sandstone and shallow marine siltstone.

The Upper Carboniferous and Lower Permian succession consists of a number of formations comprising nonmarine sandstone and conglomerate, carbonate, evaporites, and turbidites. The distribution of these lithofacies indicates a series of northeast trending facies belts. The centrally positioned evaporite–turbidite basinal belt is open to the northeast and bordered to the southeast and northwest by carbonate belts. To the southeast, the carbonate belts coalesce so that the evaporite–turbidite basinal belt terminates in that direction and is not connected with the main evaporitic basinal belt of Sverdrup Basin, which is centred on western Axel Heiberg Island. The two carbonate belts are in turn bordered to the southeast and northwest by marginal belts. A sixth facies belt is exposed in north coastal regions of the island to the north of the northwestern carbonate belt. This is the Cape Nares carbonate belt. It appears to be allochthonous and was probably emplaced by strike-slip faulting during the early Tertiary Eurekan Orogeny.

Résumé

L'extrémité nord-est du bassin de Sverdrup, qui comprend une succession concordante de strates s'échelonnant du Carbonifère inférieur au Tertiaire inférieur, affleure dans le nord-est de l'île d'Ellesmere. À cet endroit, le bassin contient une séquence complexe du socle, qui a subi un dernier plissement au cours du Silurien supérieur et du Dévonien inférieur, et localement, un grès et un conglomérat non marins du Dévonien supérieur, appartenant à la formation d'Okse Bay.

L'unité la plus ancienne du bassin de Sverdrup est la formation d'Emma Fiord, du Carbonifère inférieur, qui suit l'axe du bassin et se compose d'un conglomérat et d'un grès non marins, et d'un siltstone déposé dans une mer peu profonde.

La succession du Carbonifère supérieur et du Permien inférieur se compose de plusieurs formations englobant un grès et un conglomérat non marins, un carbonate, des évaporites et des turbidites. La distribution de ces lithofaciès indique l'existence d'une série de zones de faciès orientés vers le nord-est. La zone centrale de sédiments évaporitiques et turbiditiques de bassins est ouverte au nord-est et bordée au sud-est et au nord-ouest par des zones de sédiments carbonatés. Au sud-est, ces dernières zones fusionnent, de sorte que la zone de sédiments évaporitiques et turbiditiques de bassin se termine dans cette direction, et n'est pas reliée à la principale zone de sédiments évaporitiques du bassin de Sverdrup, qui est centrée sur l'ouest de l'île Axel Heiberg. Les deux zones de sédiments carbonatés sont à leur tour bordées au sud-est et au nord-ouest par des zones marginales. Une sixième zone de faciès affleure dans les régions côtières du nord de l'île, au nord de la zone nord-ouest de sédiments carbonatés. Elle constitue la zone carbonatée de Cape Nares. Elle semble être allochtone, et sa mise en place résulte probablement d'un décrochement survenu durant l'orogenèse eurékienne, du Tertiaire inférieur.

Summary

This report contains the results of a reconnaissance study of Devonian, Carboniferous and Permian rocks of northeastern Ellesmere Island in the Canadian Arctic Archipelago. The study area is situated northeast of Tanquary Fiord and is approximately 20 000 km^2 in size. The terrain is rugged, and elevation differences are in the order of 1000 m. More than half of the area is covered by icefields and glaciers.

Most of the rocks discussed in this report belong to the lower part of the Sverdrup Basin succession. The Sverdrup Basin formed during the Early Carboniferous as a rift basin on the folded rocks of the Franklinian Basin and Pearya. During the Carboniferous and Early Permian three subbasins existed in Sverdrup Basin. The northernmost one is the subject of this study. For the purposes of description and correlation, the succession can be subdivided into several major sequences separated by angular unconformities and disconformities.

Upper Devonian nonmarine sandstones have been assigned to the Okse Bay Formation. They overlie with angular unconformity Franklinian basement rocks that were folded during a Late Silurian-Early Devonian orogeny. The formation is estimated to be at least 1400 m thick and contains two members. The Lower member is dominated by fining-upward point bar deposits and consists of maroon conglomerate, sandstone, siltstone, and shale. The Upper member is a braided stream deposit and consists of light coloured conglomerate and sandstone. The Okse Bay Formation was only lightly affected by the Ellesmerian Orogeny, which took place during latest Devonian or earliest Carboniferous.

The Emma Fiord Formation is of Viséan age and forms the basal unit in Sverdrup Basin. It occurs in two lithofacies (nonmarine and marine) along the axis of Sverdrup Basin. The nonmarine facies is probably less than 100 m thick and consists of conglomerate and coarse sublitharenites. The marine facies is at least 700 m thick and comprises calcareous siltstone, shale, and sandy limestone.

The Upper Carboniferous and Lower Permian sequence oversteps the Okse Bay and Emma Fiord formations and is characterized by a very distinct facies distribution. The facies are arranged in well defined belts and form an elongated, symmetrical basin.

The southeastern and northwestern marginal belts are the outermost belts and consist of terrigenous clastic rocks, overlain by carbonates and evaporites. The Canyon Fiord Formation is up to 1000 m thick on the north side of the basin, whereas on the southeast it is only half that thickness. It consists of maroon conglomerate and conglomeratic sandstone; in the northern part it also contains significant amounts of fine grained sandstone and sandy limestone.

The Canyon Fiord Formation is overlain in most of the southeastern marginal belt, and locally in the northwestern belt, by the Belcher Channel Formation. The Belcher Channel Formation is variable in thickness; the maximum thickness exceeds 600 m. It consists of thick bedded, shallow marine limestone. In most parts of the northwestern belt the Canyon Fiord Formation is overlain by the Mount Bayley and Tanquary formations. The Mount Bayley Formation consists of about 400 m of anhydrite and solution breccia. The Tanquary Formation is estimated to be 500 m thick, and has a lithofacies similar to that of the Belcher Channel Formation.

The age of the formations in the marginal belts is from Moscovian to early Artinskian.

The next belt inwards, the carbonate belt, is best developed in the southwestern part of the basin. It comprises the Borup Fiord and Nansen formations. The Borup Fiord Formation is similar to the Canyon Fiord Formation, and consists of maroon conglomerate, conglomeratic sandstone, and siltstone. In the upper part of the formation the sandstone is relatively well sorted. The thickness of the Borup Fiord Formation varies greatly over short distances, but its maximum recorded thickness is 900 m. The Nansen Formation overlies the Borup Fiord Formation and is

about 1400 m thick. It consists in the lower part of alternating massive and thin bedded dolomite. In the upper part the dolomite is mainly thick bedded or massive. Locally, anhydrite and "Waulsortian" reefs occur in the middle part of the formation. The age of the formations in the carbonate belt is from Serpukhovian to early Artinskian.

The evaporite and clastic belt in the central part of the basin comprises three formations, which are, in ascending order, the Borup Fiord, Otto Fiord, and Hare Fiord formations. The Borup Fiord Formation is at least 900 m thick. In contrast to its occurrence in the carbonate belt, it consists here of maroon and green siltstone and shale, which are probably floodplain deposits. The Otto Fiord Formation exceeds 1000 m in thickness. It consists of anhydrite interbedded with minor dolomite and of interbedded sandstone and shale. The evaporites are of subaqueous origin and were precipitated simultaneously with submarine fan deposits. Only the lowest 200 m or so of the Hare Fiord Formation are preserved. They consist of local "Waulsortian" reefs and submarine fan deposits similar to those in the Otto Fiord Formation. The only age control in the basinal belt is a Moscovian dating of the reefs.

The Upper Carboniferous and Lower Permian sequence contains a fourth facies belt, the Cape Nares carbonate belt, which is situated on the extreme northern coast of Ellesmere Island and is probably of Eurekan allochthonous origin. The Cape Nares carbonate belt consists of the Borup Fiord and Nansen formations, similar to those in the main carbonate belt.

The Permian sequence consists of a number of formations, several of which rest disconformably on the Upper Carboniferous and Lower Permian sequence in an overstepping fashion, and also have disconformable relationships to each other. Facies changes are present, but are not as pronounced as in the underlying sequence. The Sabine Bay Formation is the lowest unit and is only present in the southwestern part of the study area. Maximum thickness is in the order of 150 m. The formation consists in the lower part of mature, fine grained quartzarenite, probably deposited in a nearshore, marine environment. The upper part of the formation, preserved only at a single location, consists of nonmarine siltstone and shale. The Assistance Formation overlies the Sabine Bay Formation or the Upper Carboniferous-Lower Permian sequence. It is variable in thickness, from less than 10 m to more than 200 m. Lithofacies of the formation are also variable, ranging from chert and shale of deep marine origin, to fine grained lithic greywacke deposited on a marine shelf, to fluvial conglomerate and sandstone with a northern source. The stratigraphically highest formations are the coeval Trold Fiord and Degerböls formations. The Trold Fiord Formation is 500 m thick and consists of shallow marine, mature sandstone. The formation oversteps the underlying Permian units and locally rests directly on folded lower Paleozoic basement. About 230 m of the Degerböls Formation are preserved and comprise bioclastic limestone and light coloured chert. The Upper Permian sequence ranges in age from Artinskian to Wordian.

Sommaire

Ce rapport contient les résultats d'une étude de reconnaissance faite sur les roches dévoniennes, carbonifères et permiennes du nord-est de l'île d'Ellesmere, dans l'archipel Arctique canadien. La région étudiée se situe au nord-est du fjord Tanquary, et couvre approximativement 20 000 km^2. Le terrain est accidenté, et les différences d'altitude sont de l'ordre de 1 000 m. Plus de la moitié de la région est couverte de champs de glace et de glaciers.

La plupart des roches examinées dans ce rapport appartiennent à la partie inférieure de la succession du bassin de Sverdrup. Le bassin de Sverdrup est apparu au Carbonifère inférieur sous forme d'un bassin d'effondrement, dans les roches plissées du bassin franklinien et de la Pearya. Pendant le Carbonifère et le Permien inférieur, ces trois sous-bassins ont existé dans le bassin de Sverdrup. Le plus septentrional est celui qui fait l'objet de la présente étude. Aux fins de description et de corrélation, il est possible de subdiviser la succession en plusieurs grandes séquences séparées les unes des autres par des discordances angulaires et des disconformités.

Les grès non marins du Dévonien supérieur ont été attribués à la formation d'Okse Bay. Ils recouvrent en discordance angulaire les roches franliniennes du socle, qui ont été plissées au cours d'une orogenèse survenue pendant le Silurien inférieur et le Dévonien supérieur. L'épaisseur de la formation est estimée à au moins 1 400 m, et celle-ci contient deux membres. Le membre inférieur contient principalement une séquence positive de sédiments de flèche de méandre, et se compose de conglomérat marron, de grès, de siltstone et de shale. Le membre superieur est un dépôt de cours d'eau anastomosé, et se compose d'un conglomérat et d'un grès de couleur claire. La formation d'Okse Bay n'a été que légèrement influencée par l'orogenèse ellesmérienne, qui a eu lieu à la toute fin du Dévonien ou au tout début du Carbonifère.

La formation d'Emma Fiord est d'âge viséen, et constitue l'unité basale dans le bassin de Sverdrup. Elle se présente sous forme de deux lithofaciès (un lithofaciès non marin et un lithofaciès marin) suivant l'axe du bassin de Sverdrup. Le faciès non marin a probablement moins de 100 m d'épaisseur et se compose de conglomérat et de sublitharénites grossières. Le faciès marin a au moins 700 m d'épaisseur et comprend du siltstone calcareux, du shale et du calcaire sableux.

La séquence du Carbonifère supérieur et du Permien inférieur repose en discordance stratigraphique due à une transgression sur les formations d'Okse Bay et d'Emma Fiord, et se caractérise par une distribution très distinctive des faciès. Les faciès sont disposés selon des zones bien définies, et constituent un bassin symétrique allongé.

Les zones marginales sud-est et nord-ouest constituent les zones périphériques, et se composent de roches clastiques terrigènes, recouvertes par des carbonates et par des évaporites. La formation de Canyon Fiord atteint 1 000 m d'épaisseur sur le côté nord du bassin, tandis que du côté sud-est, elle n'a que la moitié de cette épaisseur. Elle se compose d'un conglomérat marron et d'un grès conglomératique; dans sa partie nord, elle contient aussi des quantités significatives de grès fin et de calcaire sableux.

La formation de Canyon Fiord est recouverte dans la majeure partie de la zone marginale sud-est et localement dans la zone nord-ouest par la formation de Belcher Channel. La formation de Belcher Channel a une épaisseur variable; son épaisseur maximum dépasse 600 m. Elle se compose d'épaisses strates calcaires déposées en mer peu profonde. Dans la majeure partie de la zone nord-ouest, la formation de Canyon Fiord est recouverte par les formations de Mount Bayley et de Tanquary. La formation de Mount Bayley se compose d'environ 400 m d'anhydrite et de brèche de dissolution. On estime que la formation de Tanquary a 500 m d'épaisseur, et que son lithofaciès est semblable à celui de la formation de Belcher Channel.

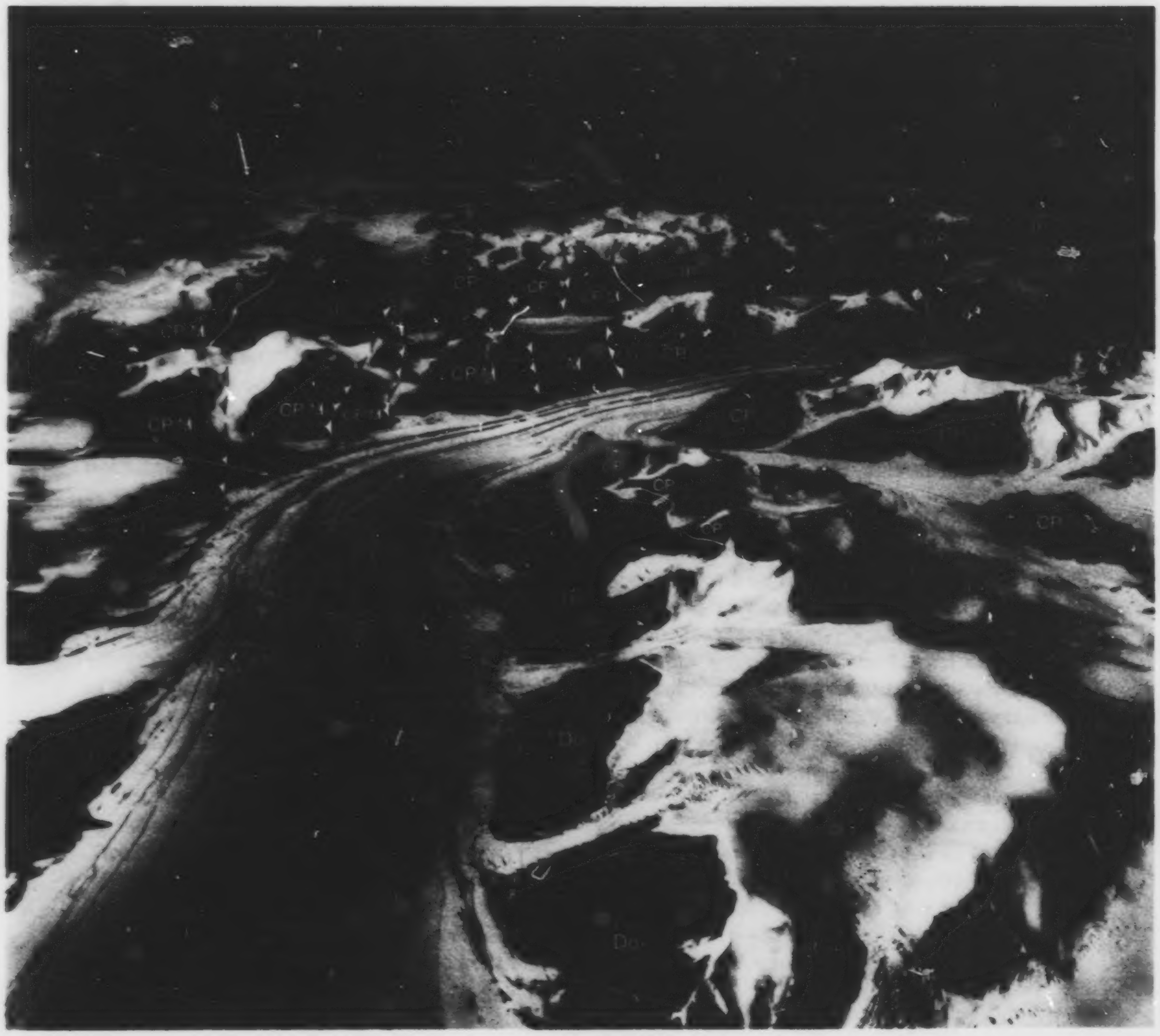
Dans les zone marginales, les formations s'échelonnent du Moscovien à l'Artinskien inférieur.

La zone intérieure suivante, la zone carbonatée, atteint son développement maximum dans la partie sud-ouest.

La zone évaporitique et clastique de la partie centrale du bassin comprend trois formations, qui de bas en haut sont les formations de Borup Fiord, d'Otto Fiord et de Hare Fiord. La formation de Borup Fiord a au moins 900 m d'épaisseur. Contrairement à la formation située dans la zone carbonatée, elle se compose ici de siltstone et de shale de couleur marron et verte, qui sont probablement des dépôts de plaine inondable. La formation d'Otto Fiord dépasse 1000 m d'épaisseur. Elle se compose d'anhydrite interstratifiée avec une dolomie mineure, et de couches alternées de grès et de shale. Les évaporites sont d'origine subaquatique, et ont précipité en même temps que se formaient des dépôts de cône sous-marin. Seuls 200 m environ à partir de la base de la formation de Hare Fiord sont encore conservés. Ils se composent de récifs locaux ''waulsortiens'' et de dépôts de cône sous-marin, semblables à ceux de la formation d'Otto Fiord. Dans la zone de sédiments du bassin, la seule délimitation de l'âge est une datation des récifs, qui remontent au Moscovien.

La séquence du Carbonifère supérieur et du Permien inférieur contient une quatrième zone de faciès, la zone carbonatée de Cape Nares, qui se situe sur la côte de l'île d'Ellesmere, tout à fait au nord de cette île, est probablement d'origine allochtone, et date de l'orogenèse eurékienne. La zone des sédiments carbonatés de Cape Nares se compose des formations de Borup Fiord et de Nansen, semblables aux formations de la zone carbonatée principale.

La séquence du Permien se compose de plusieurs formations, dont plusieurs reposent suivant une disconformité due à une transgression sur la séquence du Carbonifère supérieur et du Permien inférieur, et présentent aussi des discordances stratigraphiques les unes par rapport aux autres. Des variations de faciès existent, mais ne sont pas aussi prononcées que dans la séquence sous-jacente. La formation de Sabine Bay est l'unité la plus basse, et n'existe que dans la partie sud-ouest de la région étudiée. L'épaisseur maximum est de l'ordre de 150 m. La formation se compose dans sa partie inférieure de quartzite sédimentaire mature, à grain fin, probablement déposé dans un milieu marin infralittoral. La partie supérieure de la formation, qui n'est conservée que dans une seule localité, se compose de siltstone et de shale non marins. La formation d'Assistance recouvre la formation de Sabine Bay ou la séquence du Carbonifère supérieur et du Permien inférieur. Son épaisseur est variable, et passe de moins de 10 m à plus de 200 m. Les lithofaciès de la formation sont également variables, et du chert et du shale marins formés en mer profonde passent à une grauwacke lithique fine déposée sur une plate-forme marine, puis à un conglomérat et à un grès fluviatiles dont la source se trouve au nord. Les formations stratigraphiquement les plus hautes sont les formations de Trold Fiord et de Degerböls contemporaines. La formation de Trold Fiord a 500 m d'épaisseur et se compose de grès marin mature formé en mer peu profonde. La formation recouvre en discordance due à une transgression des unités sous-jacentes du Permien, et localement, repose directement sur le socle plissé du Paléozoïque inférieur. Environ 230 m de la formation de Degerböls se composent de calcaire bioclastique et de chert de couleur claire. La séquence du Permien supérieur s'échelonne de l'Artinskien au Wordien.



Frontispiece. Oblique aerial photograph looking west along de Vries Glacier. Major geological features include cliffs in centre foreground, which consist of Devonian Okse Bay Formation overlain unconformably by Upper Carboniferous carbonate rocks. On the far side of the glacier several thrust slices contain Upper Carboniferous, Permian, and Mesozoic formations.

lP–lower Paleozoic basement; Do–Devonian Okse Bay Formation; CP–Upper Carboniferous and Permian formations; M–Mesozoic formations. Airphoto T409L-197

INTRODUCTION

Location and scope of study

This report contains the results of a reconnaissance study of Devonian, Carboniferous, and Permian rocks of northeastern Ellesmere Island. It is part of larger project (Trettin, 1976) begun in 1975, the objective of which was the mapping and description of the stratigraphy and structure of northern Ellesmere Island. The study area is situated between the head of Tanquary Fiord, the mouth of Yelverton Inlet, and Clements Markham Inlet (Figs. 1, 2), is roughly triangular in shape, and covers approximately 20 000 km^2. More than half of this area is covered by icefields and glaciers; the terrain is rugged and some exposures are difficult to examine. Elevation differences are in the order of 1000 m.

The main staging point for operations on northeastern Ellesmere Island is a graded airstrip at the head of Tanquary Fiord, which is long enough to accommodate DC-3 aircraft. The Polar Continental Shelf Project maintains several semipermanent buildings at the airstrip. The only settlement on northeastern Ellesmere Island is Alert, consisting of an Environment Canada station and an Armed Forces base.

Fieldwork for the present study was done during the summers of 1975, 1977, 1979, and 1982. During those seasons, base camps were set up at the head of Tanquary Fiord, at the western arm of Yelverton Inlet, at the northwest side of Lake Hazen, and at the head of Clements Markham Inlet. Geological work was conducted from numerous fly camps and by helicopter traverses from the base camps.

Along the southeastern part of the ice cap, flying and operating conditions are generally good from early June to the latter part of August, but, on the ice cap and to the north of it, fieldwork is restricted to late July and early August. There the length of the season is reduced by late disappearance of snow and the frequent occurrence of fog or low clouds.

Previous work

The first account of Devonian and Carboniferous rocks on northeastern Ellesmere Island was written by Feilden and de Rance (1878) of the British naval expedition of 1875-76, who described the sequence on Feilden and Parry peninsulas. They recognized the major unconformity at the base of the Carboniferous succession and gave a general description of the units; however, their Devonian formation (Dana Bay Beds) is now considered to be of Permian age. Fossils collected during that expedition were described by Etheridge (1878). Peary's expeditions to northern Ellesmere Island between 1898 and 1909 resulted in a description of Carboniferous brachiopods (Whitfield, 1908), "said to have been collected at Cape Sheridan." No Carboniferous or Permian rocks are present at Cape Sheridan, and the described specimens may have been collected along the coast in the area around Rowan Bay, about 40 km northwest of Cape Sheridan, where the nearest exposures of Carboniferous and Permian rocks are found.

The next account of upper Paleozoic rocks in the project area was by Blackadar (1954) who, in 1953, travelled by dog team along the coast between Markham Fiord and Alert. He examined the upper Paleozoic sequence between Rowan Bay and Clements Markham Inlet, where he distinguished five informal units and refined Feilden's and de Rance's (1878) subdivisions. The north coast west of Markham Fiord was explored by Christie (1957) in 1954, also by dog team. He outlined the extent of Carboniferous and Permian rocks on Ward Hunt Island and at Cape Nares, on Marvin Peninsula, and at the heads of M'Clintock and Yelverton inlets, and pointed out the twofold division — basal redbeds overlain by thick bedded, fossiliferous limestone. In 1961, Thompson published a description of fusulinids from Ward Hunt Island, indicating the presence of Upper Carboniferous limestone along the northernmost part of the continent.

Christie (1964) published the first regional geological description of northeastern Ellesmere Island along with a summary of information existing at that time. Except for some tracts along the northern edge of the ice cap, he outlined most of the Carboniferous-Permian exposures and described the successions, but did not establish a formational nomenclature or detailed correlations between the various areas. Christie (1965) was also the first to report an "undated basal formation" of red and white sandstone in the Yelverton Pass region. These sandstones are now known to be Devonian. Operation Grantland, led by R.L. Christie in 1965 and 1966, was the first systematic study of northeastern Ellesmere Island by the Geological Survey of Canada. Several publications discussing Carboniferous and Permian rocks resulted from the field operation. Trettin (1969a) examined the upper Paleozoic succession at the head of M'Clintock Inlet. He distinguished and described five informal units and mapped their distribution. Nassichuk (1967) reported on the upper Paleozoic successions at Yelverton Pass, Henrietta Nesmith Glacier, and in several areas in the fiord country of northern Ellesmere Island. Nassichuk and Christie (1969) mapped the valley between the head of Tanquary Fiord and the head of Yelverton Fiord and defined the Tanquary Structural High, which separates Carboniferous and Permian rocks in the southeast from those in the northwest.

In 1974, Thorsteinsson published an extensive description and interpretation of the Carboniferous and Permian stratigraphy of northern Axel Heiberg and northwest Ellesmere islands, areas situated immediately to the southwest of the project area. His study contained the delineation of a number of lithofacies belts, most of which continue into the present project area, and it also contained a formal nomenclature for the various units that form these facies belts. With some minor, local adaptations, Thorsteinsson's facies belts and formational nomenclature will be used in this report.

Recently, a conodont zonation for the Carboniferous and Permian succession of parts of Sverdrup Basin has been compiled (Henderson 1981, 1988). This improvement in biostratigraphic knowledge, and the application of sequence stratigraphy, are leading to some revisions and refinements of Thorsteinsson's stratigraphy (Beauchamp et al., 1989a, b).

Acknowledgments

During this investigation, assistance and advice were received from many persons and thanks are extended to all of them. Students who assisted directly with the fieldwork were J. Calvert in 1975, D. Jones in 1977 and 1979, and J. Pulishy in 1982. All had extensive mountaineering experience, necessary for glacier traverses and some of the steeper sections. Several of the sections used in this report were measured and described by R. Gardiner, M. Oliver, and C.M. Henderson; all students participating during different years in the field parties. A.D. Miall measured and interpreted the Permian sections at the south end of Piper Pass. R.L. Christie provided the data from a measured section from Feilden Peninsula. H.P. Trettin and A. Embry were in charge of the field parties and did the major share of logistical preparation and organization. Figure 2 of this report is adapted from an unpublished manuscript map by H.P. Trettin. In 1987, B. Beauchamp and C.M. Henderson gave me a guided tour through the type section of the Belcher Channel and Assistance formations on Grinnell Peninsula and elucidated a number of Artinskian stratigraphic problems. Officers of the Polar Continental Shelf Project in Resolute supported the fieldwork with expediting services, and, during the summer of 1977, the Canadian Armed Forces Base at Alert provided food supplies.

Gratitude is also expressed to the following persons, who identified fossils and supplied information on ages and correlation: E.W. Bamber, W.W. Nassichuk, M.S. Barss, D.C. McGregor and J. Utting of the Geological Survey of Canada; B. Mamet of Université de Montréal; Liao Zhuo-ting, visiting scientist from the People's Republic of China to the Institute of Sedimentary and Petroleum Geology; C.A. Ross and B.R. Wardlaw of the United States Geological Survey. X-ray diffraction analyses and thin sections were produced at the Institute of Sedimentary and Petroleum Geology by J. Wong and W.O. McEwan, respectively.

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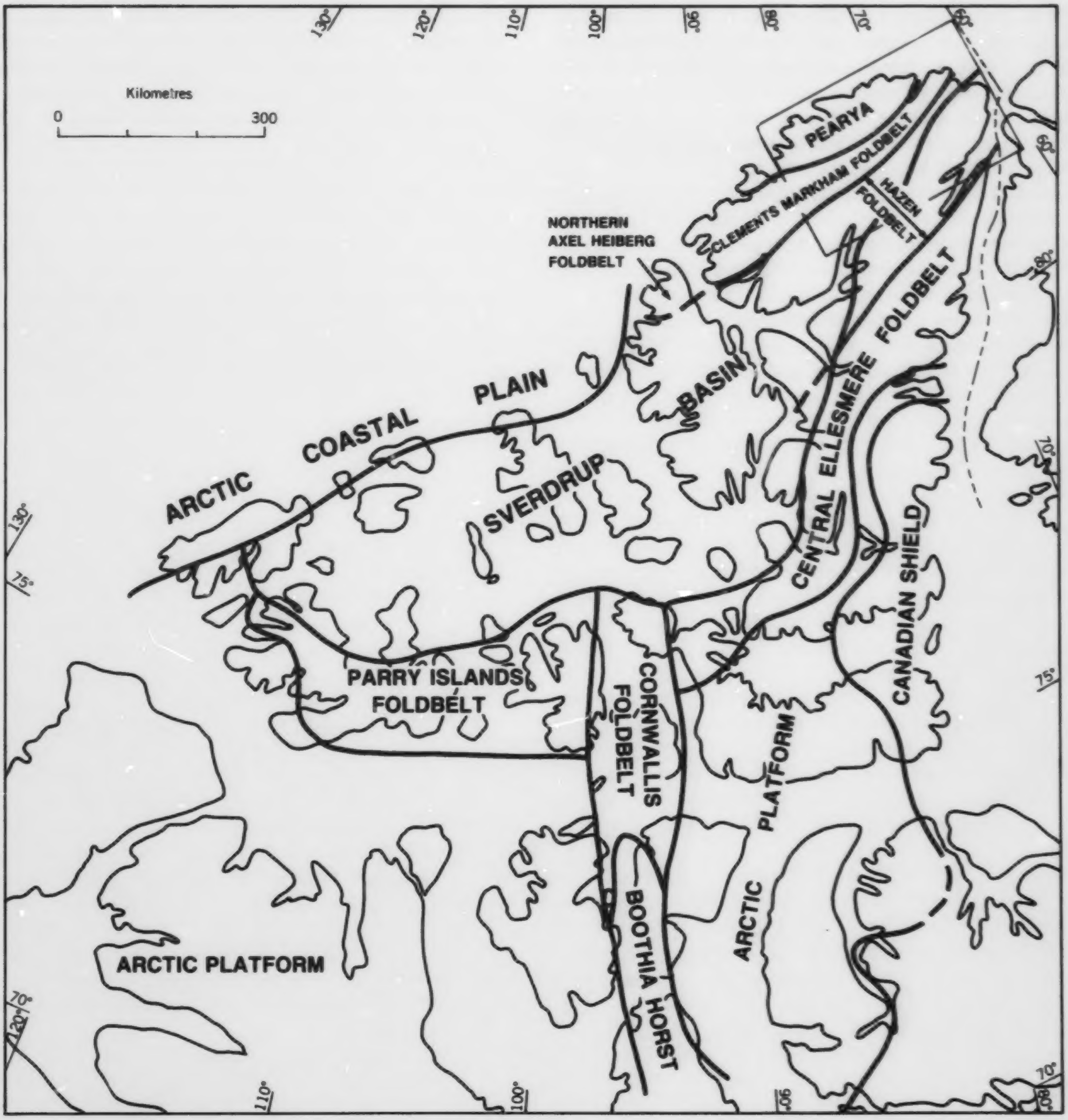
Finally, I want to thank my wife Rose-Marie for the large contribution she has made over the last two decades by her patience during my lengthy absences in summer and her ability to keep the family together in spite of that.

REGIONAL SETTING

Regional geology

The Phanerozoic succession of the Canadian Arctic Islands comprises a set of major sedimentary successions along the cratonic margin, which differ in lithological and tectonic character. The deposition of each succession was separated from the next by a significant orogeny. The oldest, the Franklinian succession, is of Cambrian to Devonian age and unconformably overlies the crystalline and sedimentary basement of the Canadian Shield. The Cambrian to Lower Devonian part of the Franklinian succession consists of carbonate rocks and evaporites deposited on a shelf to the south and east, and deep water sediments to the northwest. The Middle and Upper Devonian part of the Franklinian succession comprises a clastic wedge that prograded west and southwestward over the carbonates.

On northern Ellesmere Island, a second series of rocks, consisting of metamorphic rocks, granites, and platformal and deep water deposits, with complicated stratigraphic and structural relationships, is present northwest of the Franklinian deep water sediments. This second series is Pearya, an exotic terrane, which was accreted to the continent, probably as a number of separate slices, during the Late Silurian (Trettin, 1987).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PEARYA
CLEMENTS MARKHAM FOLDBELT
HAZEN FOLDBELT
NORTHERN AXEL HEIBERG FOLDBELT
ARCTIC COASTAL PLAIN
SVERDRUP BASIN
CENTRAL ELLESMERE FOLDBELT
CANADIAN SHIELD
PARRY ISLANDS FOLDBELT
CORNWALLIS FOLDBELT
ARCTIC PLATFORM
BOOTHIA HORST
ARCTIC PLATFORM

Figure 1. Index map of the Canadian Arctic Archipelago, showing the location of the project area on northern Ellesmere Island and regional geological subdivisions. The Canadian Shield and the Boothia Horst expose Precambrian crystalline rocks, which are overlain by Franklinian (Cambrian to Devonian) strata forming the Arctic Platform and the Cornwallis, Parry Islands, Central Ellesmere Island, Hazen, and Clements Markham fold belts. Pearya is an exotic terrane that was accreted to the continent during the Late Silurian.

Sverdrup Basin (Carboniferous to Tertiary) overlies the Franklinian sequence unconformably. On northern Ellesmere Island the Franklinian sequence consists of part of the Hazen Fold Belt, and Clements Markham Fold Belt. It also overlies Pearya.

The Franklinian succession was folded during two orogenies. On extreme northern Ellesmere and Axel Heiberg islands, the Franklinian deep water sediments adjacent to Pearya were folded during a Late Silurian or Early Devonian phase, which possibly coincided with the emplacement of Pearya. The resulting fold belts are called Clements Markham Fold Belt and Northern Axel Heiberg Fold Belt (Trettin, 1987). The remainder of the Franklinian deep water sediments and the adjacent shelf carbonates were folded during the Ellesmerian Orogeny of latest Devonian or earliest Carboniferous time. The southern and southeastern part of the shelf sediments were not folded at all and remained a stable platform. The folded deep water sediments form the Hazen Fold Belt, and the folded shelf sediments constitute the Central Ellesmere Fold Belt (Fig. 1). Farther southwest, the north-south trending Cornwallis Fold Belt was formed at approximately the same time as the Clements Markham and Northern Axel Heiberg fold belts; the east-west trending Parry Islands Fold Belt to the west is of Ellesmerian origin.

The third sedimentary succession in the Canadian Arctic Islands comprises the evaporites, carbonate rocks, shales and sandstones of Sverdrup Basin. Sverdrup Basin formed during the Early Carboniferous as a rift basin (Balkwill and Fox, 1982) on the folded Franklinian rocks and Pearya. The axis extended from Clements Markham Inlet in the northeast to Prince Patrick Island in the southwest. The southeast margin of Sverdrup Basin was

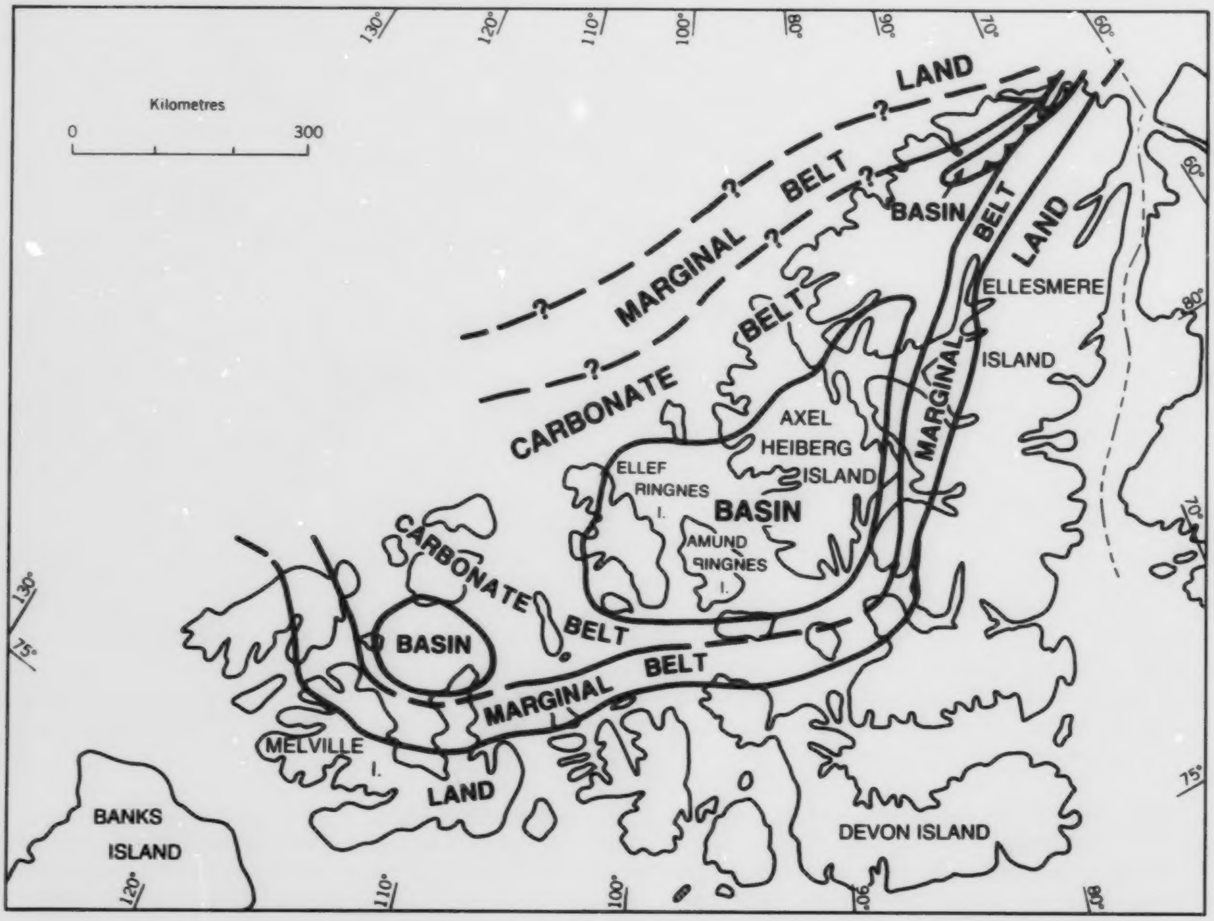

130°
120°
110°
100°
80°
90°
70°
60°
Kilometres
0
300
LAND
MARGINAL BELT
?
BASIN
BELT
LAND
ELLESMERE
ISLAND
MARGINAL
CARBONATE BELT
AXEL HEIBERG ISLAND
ELLEF RINGNES I.
BASIN
AMUND RINGNES I.
CARBONATE BELT
BASIN
MARGINAL BELT
MELVILLE I.
LAND
BANKS ISLAND
DEVON ISLAND
75°
80°
70°
60°

Figure 3. Upper Carboniferous facies belts of Sverdrup Basin. Three subbasins, characterized by evaporites and turbidites, were present north of Melville Island, in the Ringnes Islands–Axel Heiberg area and on northern Ellesmere Island. The present, elongate shape of the basin on northern Ellesmere Island is probably more a result of Tertiary structural shortening across the basin axis than of original depositional configuration.

in proximity to the main source areas, and the sediments there were dominated by coarser clastic rocks (Embry, in press). The depocentres of Sverdrup Basin shifted throughout its history. During the Late Carboniferous three subbasins existed, characterized by evaporites and submarine fan deposits (Fig. 3); the central and largest one centred on western Axel Heiberg, a smaller one in the west, centred north of Sabine Peninsula (Meneley et al., 1975), and a third one, newly described in this report, in northeastern Ellesmere Island. By Permian time, although an axial region could still be distinguished, the subdivisions of Sverdrup Basin were much less distinct. Regional subsidence of Sverdrup Basin continued through Triassic to early Tertiary time; after that, the early phases of the Eurekan Orogeny localized subsidence, and, during Middle Eocene to Early Miocene time, the main compressional phase of the Eurekan Orogeny (Trettin and Balkwill, 1979) ended deposition in Sverdrup Basin. The effects of Eurekan compression varied and increased from southwest to northeast. Broad folds are present in the western half of the archipelago, whereas more intense folding and some thrusting occurred on Axel Heiberg Island and western Ellesmere Island. The most intense deformation, with extensive thrusting and tight folding, occurred in northern Ellesmere Island. This severe shortening may have been related to the opening of Baffin Bay and the convergence of northern Greenland and northern Ellesmere Island (Okulitch et al., 1990). Additionally, braided fault patterns in the Porter Bay Fault Zone indicate strike-slip components for the structures of northern Ellesmere Island.

The fourth and last sedimentary succession of the Canadian Arctic Islands are the sediments of the Arctic Coastal Plain, which onlap onto the folded Sverdrup Basin rocks along the present continental margin (Fig. 1). They range in age from Miocene to Recent.

Local structural history and relationships

As mentioned in the previous section, northern Ellesmere Island was severely deformed during the Eurekan Orogeny; upper Paleozoic and Mesozoic formations have been overthrust by lower Paleozoic units, and thrusting within the Sverdrup Basin succession is common. Tight folding and overturned panels are also present. In the central part of the map area, some fine grained rocks have secondary, plicated cleavage; locally, grains in limestone are aligned and skeletal fragments are attenuated. The interpretation of some of the large thrusts and faults has implications on the stratigraphic interpretation and vice versa. Structural and stratigraphic interpretations are interdependent and the available data do not allow for a unique geological solution. Eurekan structures in the area have not been studied in detail and interpretation is hindered by the extensive ice cover; nevertheless, some structural features relevant to the stratigraphy will be discussed briefly. Of particular importance in this context are the Parr Bay Fault (Trettin, 1987) in the Cape Nares area, the Crescent Glacier Fault (new) in the Markham River area, and the Porter Bay Fault Zone (Fig. 2). To date, no regional description or interpretation of Eurekan structures on northern Ellesmere has been published. Osadetz (1982) studied the faults around the head of Tanquary Fiord and came to the conclusion that thin-skinned models of deformation could be applied and that tectonic shortening might be substantial. Higgins and Soper (1983) published an alternative interpretation of the area around the head of Tanquary Fiord, which made tectonic transpression and minor dextral strike-slip, and the resulting basement upthrust, the structural driving force. Nassichuk and Christie (1969) defined the Tanquary Structural High between the head of Tanquary Fiord and Yelverton Pass. This is an area where Carboniferous and Permian rocks are missing and Upper Triassic formations rest directly on folded lower Paleozoic basement. They argued that the structural high was the result of Triassic faulting and of the stripping of Permo-Carboniferous and Lower Triassic deposits prior to the deposition of Upper Triassic units. Subsequently, the tectonic history of the Tanquary High has been described more precisely. According to Maurel (1989), the Tanquary High is a fault-controlled saddle of Carboniferous age that crossed the general axis of Sverdrup Basin in an oblique, east-west direction. This caused an offset of the local axes of the central and northern Ellesmere subbasins of Sverdrup Basin.

Based on the work of these authors and on observations during the present fieldwork, a brief, albeit still incomplete, outline of the local post-Carboniferous structural history of the project area follows. Three distinct phases can be distinguished:

1. Late Permian and Early Triassic faulting and uplift. This phase is most obvious on the Tanquary Structural High. A fault, probably no older than Late Permian and no younger than Late Triassic is exposed at the north side of Yelverton Pass (Fig. 4). Late Permian faulting and uplift are indicated by the fact that Upper Permian Trold Fiord Formation rests directly on lower Paleozoic rocks (Fig. 36) at the southern entrance of Piper Pass, while, less than 30 km to the north and west, substantial thicknesses of the Carboniferous and Lower Permian succession are present. The rock types in this succession do not indicate the proximity of a contemporary basin margin; thus, they most likely have been uplifted and stripped in the Piper Pass region.

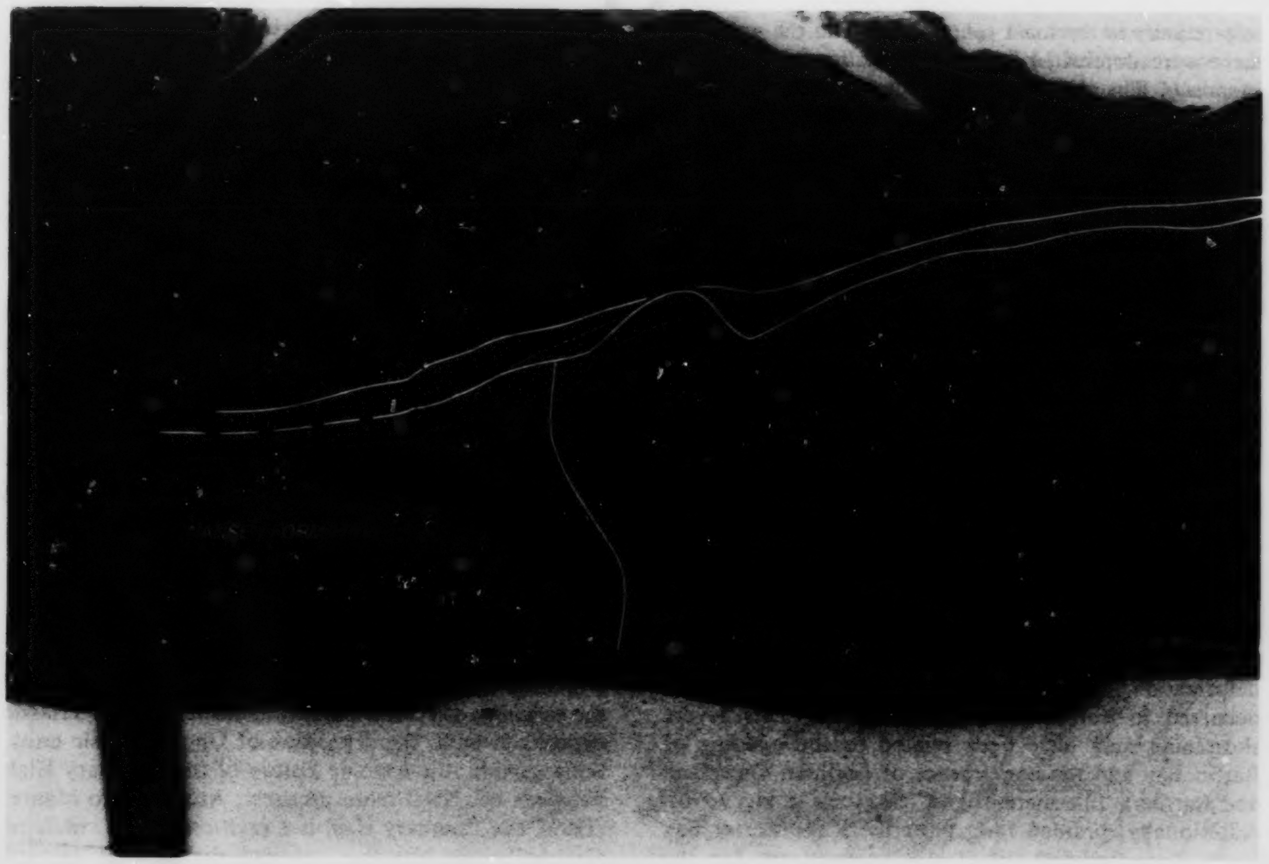
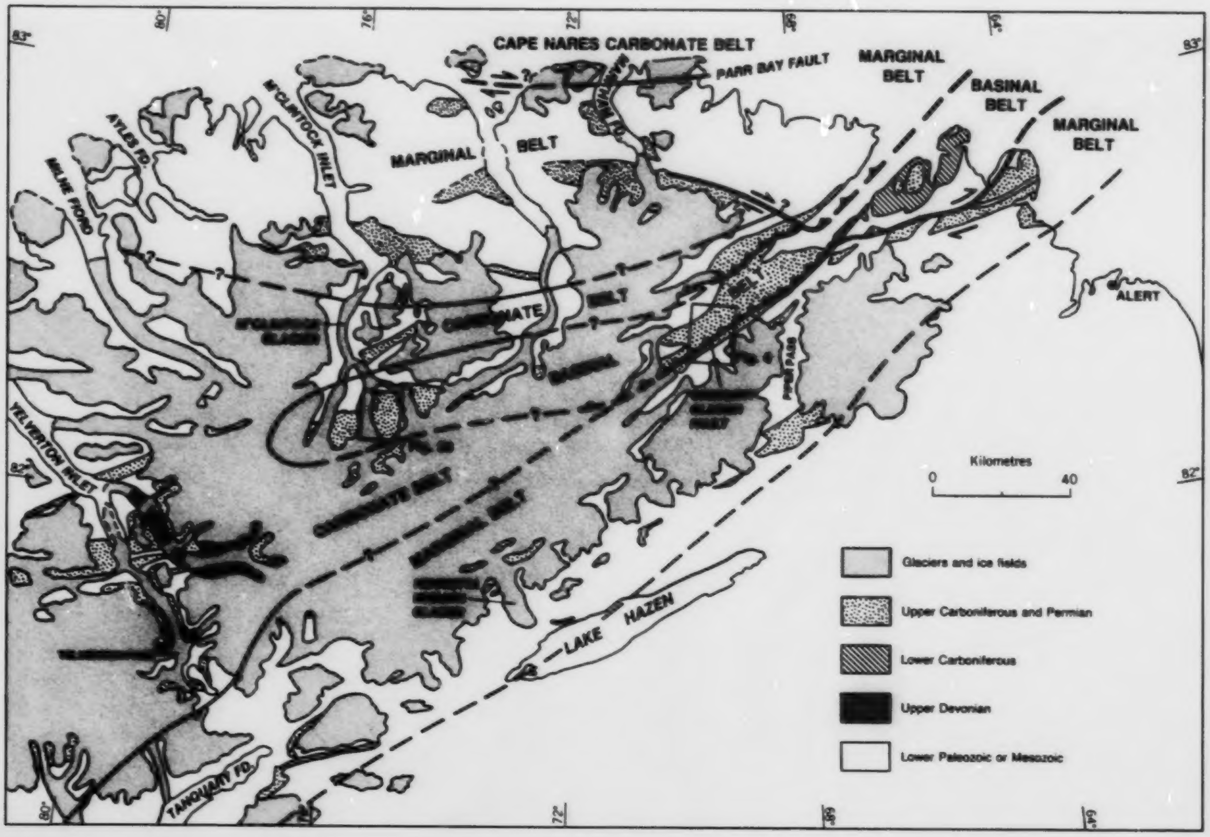


Figure 4. Pre-Upper Triassic fault at Yelverton Pass. This fault places Nansen Formation and Okse Bay Formation in juxtaposition and both formations are overlain unconformably by the Upper Triassic Heiberg and Barrow formations. Displacement along the fault could be in the order of several thousands of metres. ISPG photo. 2525-25.

2. Late Cretaceous-early Tertiary uplift. Tertiary (Christie, 1964) conglomerate and breccia (now assigned to the Eureka Sound Formation) occur at various locations near M'Clintock Inlet in the northern part of the ice cap. They unconformably overlie different Carboniferous formations and consist mainly of Carboniferous carbonate clasts. Christie's (1964) sample has been reexamined, and a tentative Oligocene or Miocene age has been assigned to it (D.J. McIntyre, pers. comm., 1985). During the course of this fieldwork, additional samples were collected near Christie's location and from other exposures, but all were barren. The conglomerate indicates uplift and peneplanation questionably prior to the Oligocene. Lower Cretaceous beds are preserved at Lake Hazen and farther to the southwest, providing the earlier age limit for the uplifting event. The present Sverdrup Basin has the outline of a southwest plunging synclinorium, and northern Ellesmere Island contains the structurally highest parts of Sverdrup Basin. This configuration probably results from Cretaceous-Tertiary uplift.

3. Eurekan (Tertiary) compression. Response to the compression varied according to rock type. In the carbonate and marginal belts it resulted mostly in thrusting, with some thrust planes dipping northwest and others southeast. The shales and evaporites in the basinal area responded by tight folding.

The narrowing of the basinal belt, and the apparent absence of the northwestern and southeastern carbonate belts in the Clements Markham Inlet area (Fig. 5), can be attributed to a number of causes, all probably involved to varying degrees in the shaping of the belt outline, as shown in Figure 5. The lines on the map reflect subjective



83°
80°
76°
72°
68°
64°
83°
82°
82°
CAPE NARES CARBONATE BELT
PARR BAY FAULT
MARGINAL BELT
BASINAL BELT
MARGINAL BELT
MARGINAL BELT
CARBONATE BELT
AYLES FD.
MILNE FIORD
M'CLINTOCK INLET
YELVERTON INLET
TANQUARY FD.
LAKE HAZEN
ALERT
PIPER PASS
Kilometres
0
40
Glaciers and ice fields
Upper Carboniferous and Permian
Lower Carboniferous
Upper Devonian
Lower Paleozoic or Mesozoic

Figure 5. Index map of northern Ellesmere Island, showing the locations of the vertical airphotos in Figures 6 and 30, and the Upper Carboniferous facies belts. The present boundaries of the facies belts are in part determined by Eurekan (Tertiary) structures. The Parr Bay Fault is interpreted as a dextral strike-slip fault that places shelf carbonates of the Cape Nares Carbonate Belt north of the sediments of the marginal belt, into the presumed source area of these sediments. The Crescent Glacier Fault thrusts basinal facies over marginal facies and the normally intervening carbonate belt facies is presumed to be missing because of that thrust. The northern area of the carbonate belt is missing on the north side of Clements Markham Inlet. The map shows a fault, interpreted as a dextral-slip fault, placing marginal belt facies on strike with carbonate belt facies.

decisions about assigning outcrops to the carbonate or marginal belt in transitional areas or in incomplete sections. It is also not known how much crustal shortening took place when the carbonate belts were overthrust by the basinal and marginal belts. Tectonic activity was certainly the dominant cause of the elimination of the southeastern carbonate belt at the surface.

The main argument for this conclusion is based on the Crescent Glacier Fault, along which basinal shale and evaporites are thrust over lithofacies of the southeastern Sverdrup margin (Figs. 5, 6). The Crescent Glacier Fault emerges as a thrust from under the ice cap at the bend of Crescent Glacier, from whence it extends northeast for about 30 km as far as the unnamed river that originates from Piper Pass. Along its trace, shale, sandstone, and evaporites of the Otto Fiord Formation are thrust over carbonate rocks and breccias of the Antoinette and Mount Bayley formations (Fig. 7). The fault is overturned along parts of its course. Northeast of the unnamed river, the Crescent Glacier Fault does not appear to be a thrust fault and extends from there to the southeastern shore of Clements Markham Inlet.

Similarly, the northern boundary fault of the Porter Bay Fault Zone is a major facies separation line. To the south, the formations in the graben of the Porter Bay Fault Zone belong to the marginal belt, whereas, less than 3 km to the north of the boundary fault, Emma Fiord

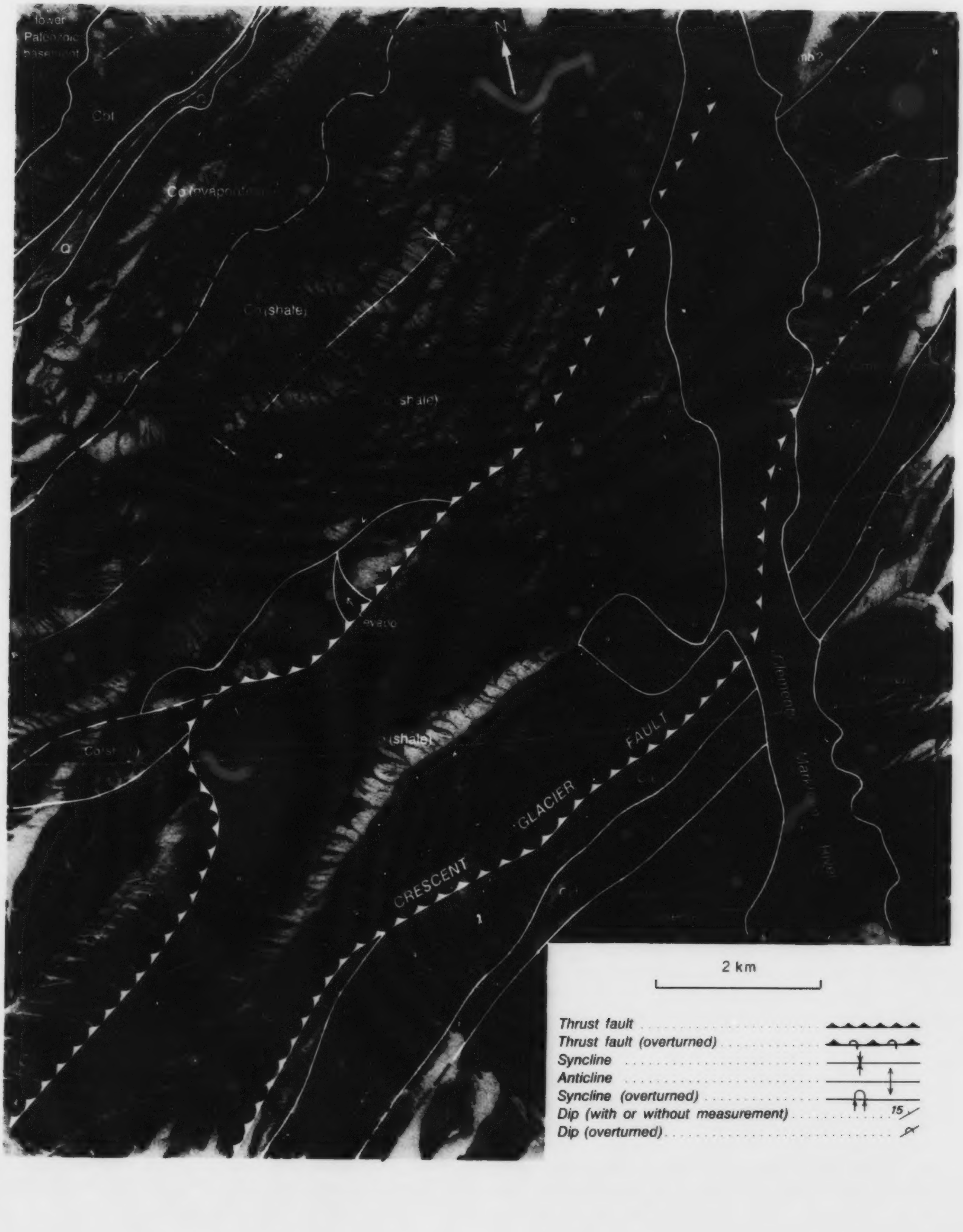

lower Paleozoic basement
N
Cbt
Q
Co (evaporite)
Co (shale)
(shale)
evapo
Co (shale)
(shale)
CRESCENT GLACIER FAULT
Clemenceau
River
mb?
2 km
Thrust fault
Thrust fault (overturned)
Syncline
Anticline
Syncline (overturned)
Dip (with or without measurement)
15
Dip (overturned)

Figure 6. (Left) Vertical airphoto showing part of the Crescent Glacier Fault, and location of Sections K and L. Along the fault, shale and evaporite of the Otto Fiord Formation are thrust over breccia and dolomite of the Mount Bayley and Antoinette formations. Equivalents of the Nansen Formation are missing in this area and are presumed to form the subsurface portion of the footwall. A second thrust places slates of the Borup Fiord Formation over Otto Fiord Formation.

Also shown are locations of Figures 7 and 33. See Figure 5 for location of airphoto NAPL A-16607-127.

Q–Quaternary fluvial sediments: Cmb–Mount Bayley Formation breccia; Ca–Antoinette Formation dolomite; Ccf–Canyon Fiord Formation conglomerate and sandstone; Co–Otto Fiord Formation shale and evaporite; Cbf–Borup Fiord Formation red and green slate. Geological symbols as in Figure 2.

Formation and Borup Fiord Formation of basinal character are present. The northern boundary fault appears to merge into the Crescent Glacier Fault, but more detailed structural mapping is needed to confirm this.

Along the northwest side of Clements Markham Inlet, basinal rocks are separated from units of the northwestern carbonate belt by large, northeasterly trending faults. Total width of the basinal lithofacies belt is here only about 10 km, and the faults are, presumably, thrusts with a southeasterly transport direction. Surface traces of the faults indicate steep or vertical dips, but the possibility of folding of the fault planes, similar to the local overturning of the Crescent Glacier Fault, cannot be excluded.

CRESCENT GLACIER FAULT

Figure 7. The Crescent Glacier Fault places sandstone and shale of the Otto Fiord Formation "over" evaporite solution breccia of the Mount Bayley Formation. At this particular location the entire sequence, including the fault plane, is overturned. Skyline is formed by resistant weathering Mount Bayley Formation. See Figure 6 for location on airphoto. ISPG photo. 2525-15.

In addition to significant amounts of structural shortening, the possibility of Eurekan strike-slip movement must be taken into account when making stratigraphic interpretations of northern Ellesmere Island. The Porter Bay Fault Zone is a tectonic graben that extends from Feilden Peninsula to the northern entrance of Piper Pass, where it bends south and appears to end. It is bounded on both sides by very sharp, well defined faults. The southeastern fault is called the Porter Bay Fault (Mayr et al., 1982a); the northwest one is unnamed. The graben fill consists of strongly folded Carboniferous and Permian beds, the fold axes of which are oblique to the trend of the graben. Faults within the graben are similarly oblique to the main trend and exhibit the braided pattern characteristic of strike-slip zones. Another strike-slip zone is suspected to exist along the east–west arm of de Vries Glacier and to extend across the unnamed peninsula between de Vries Glacier and Yelverton Inlet. This assumption is based on the complex braided fault pattern on the peninsula, and in the exposures of major faults along the northern edge of de Vries Glacier. Braided faults merging with the Crescent Glacier Fault imply a strike-slip component there also. The fault that runs up Gypsum River on the north side of Clements Markham Inlet also is interpreted as having a strike-slip component. It places northwestern carbonate belt sequence strata on strike with strata tentatively assigned to the northwestern marginal belt.

The question of Tertiary strike-slip movement also enters the stratigraphic interpretation in the Cape Nares area. There, the Parr Bay Fault separates different successions of Pearya and has been interpreted as a Silurian strike-slip fault (Trettin, 1987). It is also the nearest fault south of the Cape Nares Carboniferous carbonates, which create some problems in paleogeographic interpretation (see the sections on the Canyon Fiord and Nansen formations for details). The Parr Bay Fault is one of the lower Paleozoic faults of Pearya that was reactivated during post-Carboniferous time, and the vertical components of those movements are obvious; however, strike-slip movements cannot be ruled out (Trettin, 1987), even though they have not been independently confirmed yet.

Stratigraphic outline

The Devonian, Carboniferous, and Permian succession of northern Ellesmere Island contains several unconformities that provide natural breaks and can be used to subdivide the succession into several sequences (Fig. 8, Table 1).[1]

1. Upper Devonian sequence. Upper Devonian nonmarine sandstones on northern Ellesmere Island have been assigned to the Okse Bay Formation. They overlie with angular unconformity the Clements Markham Fold Belt, which was deformed in Late Silurian–Early Devonian.

2. Lower Carboniferous sequence. Lower Carboniferous rocks, ranging from nonmarine to marine, belong to the Emma Fiord Formation. The Emma Fiord Formation lies with angular unconformity on Clements Markham Fold Belt units. A contact with the Okse Bay Formation was not observed; it is probably a gentle angular unconformity. The Emma Fiord Formation is the oldest formation of the Sverdrup Basin.

3. Upper Carboniferous and Lower Permian sequence. Units of this sequence overstep both the Okse Bay Formation and the Emma Fiord Formation. Whereas occurrences of the Emma Fiord Formation are restricted to the axial part of Sverdrup Basin, Upper Carboniferous and Lower Permian rocks are of wider extent. Their thickness is also several times that of the underlying or overlying sequences. The sequence is characterized by very distinct facies changes, which follow a pattern similar to that described by Thorsteinsson (1974) for the area immediately southwest of the area under discussion here. A number of belts, forming an elongated, symmetrical basin, can be recognized (Figs. 5, 8):

    a. The southeastern marginal belt comprises terrigenous clastic rocks, carbonates and breccia not older than Moscovian. The Canyon Fiord Formation consists of red conglomerate and sandstone and is, in the southwest part of the belt, overlain by the limestone of the Belcher Channel Formation; in the northwest part of the belt it is overlain by the Antoinette and Mount Bayley formations, which respectively consist of carbonate and evaporite solution breccia.

    b. The carbonate belt surrounds the southwestern part of the basin and extends on the northwest side as far as Clements Markham Inlet. It comprises red conglomerate and sandstone of Serpukhovian and Bashkirian age (Borup Fiord Formation), which are overlain by massive carbonate rocks (Nansen Formation). Locally,

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[1] The term "sequence" is used here in the sense of Thorsteinsson (1974) to group a number of formations together for purposes of description and correlation. Beauchamp et al. (1989a, b) use the term in the strict sense of sequence stratigraphy.

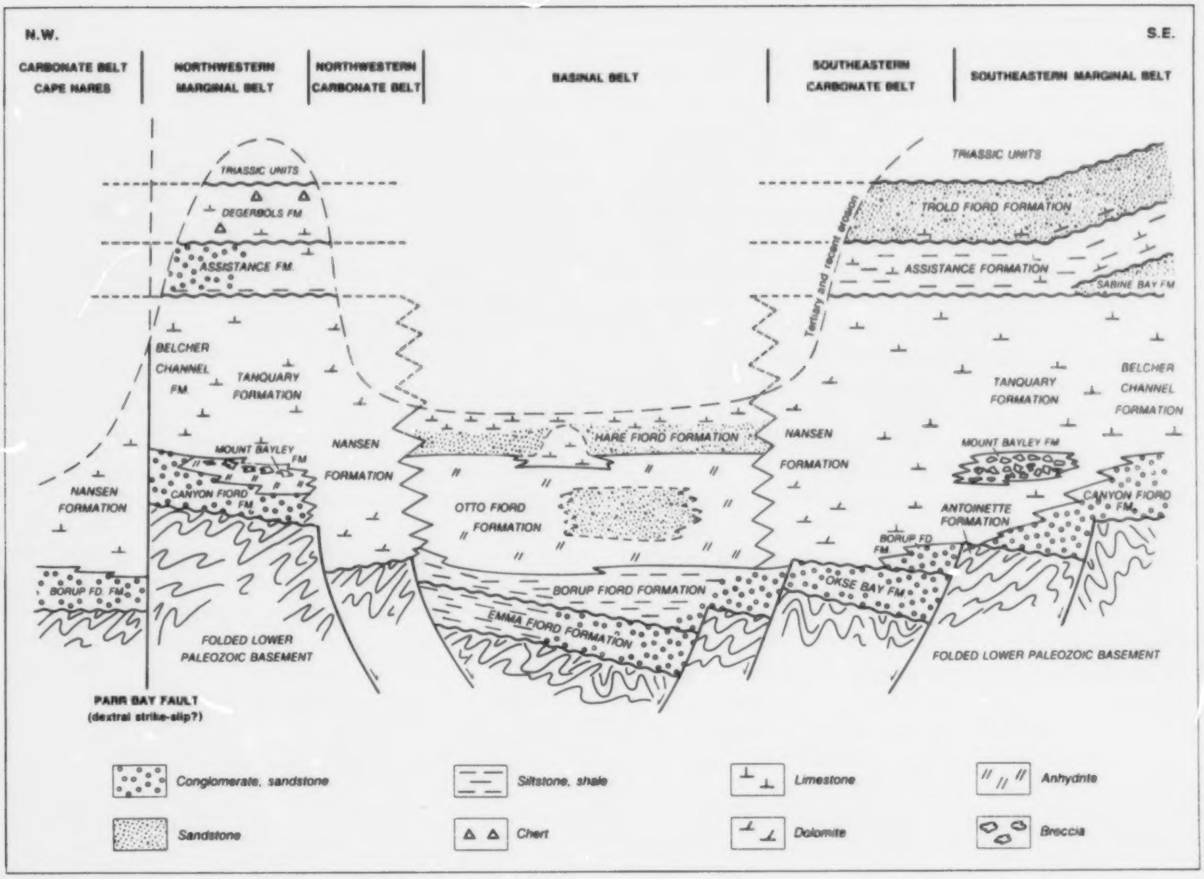

N.W.
S.E.
CARBONATE BELT CAPE NARES
NORTHWESTERN MARGINAL BELT
NORTHWESTERN CARBONATE BELT
BASINAL BELT
SOUTHEASTERN CARBONATE BELT
SOUTHEASTERN MARGINAL BELT
TRIASSIC UNITS
DEGERBOLS FM
ASSISTANCE FM
BELCHER CHANNEL FM
TANQUARY FORMATION
MOUNT BAYLEY FM
CANYON FIORD FM
NANSEN FORMATION
BORUP FD. FM
FOLDED LOWER PALEOZOIC BASEMENT
PARR BAY FAULT (dextral strike-slip?)
HARE FIORD FORMATION
OTTO FIORD FORMATION
BORUP FIORD FORMATION
EMMA FIORD FORMATION
TROLD FIORD FORMATION
Tertiary and recent erosion
ASSISTANCE FORMATION
SABINE BAY FM
BELCHER CHANNEL FORMATION
ANTOINETTE FORMATION
BORUP FD FM
OKSE BAY FM
Conglomerate, sandstone
Sandstone
Siltstone, shale
Chert
Limestone
Dolomite
Anhydrite
Breccia

Figure 8. Diagrammatic, northwest-southeast stratigraphic cross-section.

the Borup Fiord Formation is not present and the Nansen Formation rests directly on Okse Bay Formation or on units of the Clements Markham Fold Belt. Formations of the carbonate belt are not exposed on the southeast side of Clements Markham Inlet. There, formations of the basinal facies are thrust over units of the southeastern marginal belt along the Crescent Glacier Fault, and presumably also tectonically overlie the Nansen and Borup Fiord formations.

c. The basinal evaporitic and clastic belt includes, in ascending order, siltstone and slate of the Borup Fiord Formation, evaporites, shale and sandstone of the Otto Fiord Formation, and sandstone and thin bedded limestone of the Hare Fiord Formation. The basinal belt is confined on the southwest by the Nansen and Borup Fiord formations of the carbonate belt; in the northeast it continues beneath the ocean.

d. The northwestern marginal belt is similar to the southeastern marginal belt. At the base it contains sandstone and conglomerate of the Canyon Fiord Formation. These are overlain by evaporites and breccia of the Mount Bayley Formation, which in turn is overlain by limestone of the Tanquary Formation. At central Markham Fiord, the evaporites are not present and the limestone is assigned to the Belcher Channel Formation.

e. The Cape Nares carbonate belt is present along the extreme northern edge of Ellesmere Island and contains sandstone and conglomerate of the Borup Fiord Formation and carbonates of the Nansen Formation. The presence of this carbonate belt raises some problems, either stratigraphic or tectonic, which are discussed in the sections on the Canyon Fiord Formation and the Cape Nares carbonate belt.

4. Permian sequence. The Permian sequence consists of a number of formations, several of which rest disconformably on the Upper Carboniferous and Lower Permian sequence in an overstepping fashion, and also have disconformable relationships to each other. Facies changes are present, but are not as pronounced as in the Upper Carboniferous-Lower Permian sequence. The sandstone of the Sabine Bay Formation is present only in the southwestern part of the project area. The Sabine Bay Formation is the lowest unit of this sequence and pinches out northeastward. The Sabine Bay Formation or the Upper Carboniferous-Lower Permian sequence are overlain by shale and silty limestone of the Assistance Formation. The stratigraphically highest formations are the Trold Fiord and Degerböls formations. The Trold Fiord Formation consists of sandstone and sandy limestone and overlies the Assistance Formation disconformably, or oversteps onto folded lower Paleozoic units of the Hazen Fold Belt. The Degerböls Formation consists of chert and limestone, equivalent to the Trold Fiord Formation. The Degerböls Formation is present only at the head of Markham Fiord.

UPPER DEVONIAN AND LOWER CARBONIFEROUS FORMATIONS

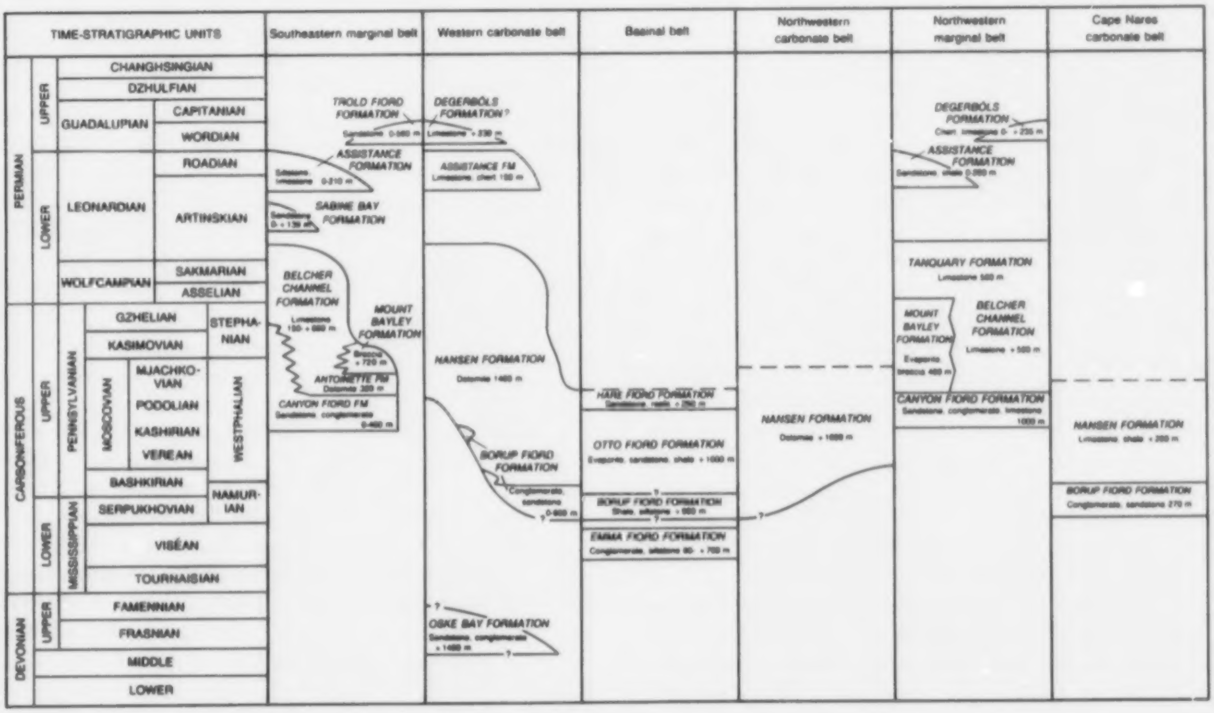
Okse Bay Formation

Definition and contact relationships. McLaren (1963) used the term Okse Bay Formation to define about 3000 m of nonmarine sandstone and shale in the Okse Bay area on southern Ellesmere Island. He subdivided the formation into four members. Embry and Klovan (1976) raised the formation to group status and divided it into five formations, which correspond in large part to the four original members.

These formations are, in ascending stratigraphic order: the *Strathcona Sound Formation*, consisting of reddish sandstone, siltstone, shale, and minor limestone; the *Hecla Bay Formation*, comprising light coloured, mature sandstone; the *Fram Formation*, which consists of sandstone alternating with red and green shale-siltstone units; the *Hell Gate Formation*, which, similar to the Hecla Bay Formation, mainly comprises white sandstone; and the *Nordstrand Point Formation*, which is the highest formation of the Okse Bay Group and is made up of sandstone and greenish siltstone-shale units. The age of

TABLE 1

Correlation of formations


TIME-STRATIGRAPHIC UNITS
Southeastern marginal belt
Western carbonate belt
Basinal belt
Northwestern carbonate belt
Northwestern marginal belt
Cape Nares carbonate belt
PERMIAN
UPPER
LOWER
CHANGHSINGIAN
DZHULFIAN
GUADALUPIAN
CAPITANIAN
WORDIAN
ROADIAN
LEONARDIAN
ARTINSKIAN
WOLFCAMPIAN
SAKMARIAN
ASSELIAN
CARBONIFEROUS
PENNSYLVANIAN
GZHELIAN
KASIMOVIAN
STEPHANIAN
MOSCOVIAN
MJACHKOVIAN
PODOLIAN
KASHIRIAN
VEREAN
WESTPHALIAN
BASHKIRIAN
MISSISSIPPIAN
SERPUKHOVIAN
NAMURIAN
VISÉAN
TOURNAISIAN
DEVONIAN
FAMENNIAN
FRASNIAN
MIDDLE
LOWER
TROLD FIORD FORMATION
Sandstone 0-560 m
DEGERBÖLS FORMATION?
Limestone +230 m
ASSISTANCE FORMATION
Siltstone, Limestone 0-210 m
ASSISTANCE FM
Limestone, chert 150 m
SABINE BAY FORMATION
Sandstone 0-+130 m
BELCHER CHANNEL FORMATION
Limestone 150-+880 m
MOUNT BAYLEY FORMATION
Breccia +720 m
ANTOINETTE FM
Dolomite 320 m
CANYON FIORD FM
Sandstone, conglomerate 0-460 m
HANSEN FORMATION
Dolomite 1460 m
BORUP FIORD FORMATION
Conglomerate, sandstone 0-800 m
?
OSKE BAY FORMATION
Sandstone, conglomerate +1480 m
HARE FIORD FORMATION
Sandstone, reefs +250 m
OTTO FIORD FORMATION
Evaporite, sandstone, shale +1000 m
BORUP FIORD FORMATION
Shale, siltstone +550 m
EMMA FIORD FORMATION
Conglomerate, siltstone 80-+700 m
HANSEN FORMATION
Dolomite +1600 m
DEGERBÖLS FORMATION
Chert, limestone 0-+235 m
ASSISTANCE FORMATION
Sandstone, shale 0-300 m
TANQUARY FORMATION
Limestone 500 m
MOUNT BAYLEY FORMATION
Evaporite, breccia 400 m
BELCHER CHANNEL FORMATION
Limestone +500 m
CANYON FIORD FORMATION
Sandstone, conglomerate, limestone 1000 m
HANSEN FORMATION
Limestone, shale +200 m
BORUP FIORD FORMATION
Conglomerate, sandstone 270 m

the Okse Bay Group in the type area on southern Ellesmere Island is Eifelian to late Frasnian. West of the type area, on Grinnell Peninsula, the Okse Bay Group is disconformably overlain by the Frasnian-Famennian Parry Islands Formation (Embry and Klovan, 1976), which consists of orange to white sandstone with some shale and siltstone intervals. In the present study, the Okse Bay is retained as a formation with two members — a lower member of red sandstone and siltstone, and an upper member of white sandstone and conglomerate. The reason for this is the uncertain correlation of the two members with the formations of the Okse Bay Group.

The rocks here assigned to the Okse Bay Formation were first mentioned by Christie (1965) who reported an undated formation with two units: a lower, red weathering shale and sandstone unit; and an upper, white conglomerate and sandstone unit, from Yelverton Pass. Nassichuk and Christie (1969) measured two sections, 3 and 13 miles north or northwest of Yelverton Lake, which, according to them, contained the Borup Fiord and Nansen formations. In the section three miles north of the lake they incorrectly assigned Christie's (1969) red weathering shale and sandstone units to the Carboniferous Borup Fiord Formation, and the white, conglomerate and sandstone unit to the Nansen Formation. A similar, incorrect correlation was used by Mayr (1976) for the same units, but palynological evidence (Appendix 3) has now shown that these rocks are of Devonian age. The redbeds and light coloured sandstone and conglomerate of Nassichuk and Christie's (1969) second section, 13 miles northwest of the lake, were correctly assigned by them to the Borup Fiord Formation and lowest Nansen Formation.

The lower boundary of the Okse Bay Formation in the project area has not been observed. The beds are only slightly tilted, whereas the pre-Devonian rocks (Imina and Grantland formations) in the vicinity of Yelverton Pass are steeply inclined. There is, presumably, a significant angular unconformity between the Okse Bay Formation and the pre-Devonian units; however, it is also possible that the Okse Bay Formation does not rest directly on pre-Devonian formations but may be underlain by additional marine Devonian units.

The upper boundary is an angular unconformity with upper Paleozoic carbonates or Triassic formations.

Distribution and thickness. The Okse Bay Formation is present in two areas. One is on the immediate northwestern side of Yelverton Pass (Fig. 4) where the exposed part of the Lower member is 280 m thick and the Upper member is 320 m thick. The other is in the cliffs and nunataks along the east-west part of the de Vries Glacier (Fig. 9), where thickness estimates are 360 m for the exposed part of the Lower member, and 1000 m for the Upper member.

Lithology. The Okse Bay Formation consists of interbedded conglomerate, sandstone, siltstone, shale, and minor argillaceous limestone. The two members are distinguished by the amount of interbedded siltstone and shale. The Lower member consists of white sandstone and conglomerate, interbedded with mostly maroon shale and siltstone (about 30 per cent), and minor argillaceous limestone. The finer grained rock types are concentrated in the lower part of the member. The Upper member consists of white sandstone and conglomerate; the interbedded, fine grained, maroon rock types are insignificant and occur mostly as discontinuous partings. Seen from a distance, the Lower member is reddish, recessive and appears to be overlain sharply by the resistant, rusty-white weathering Upper member. The formation was studied in detail at Section A and the following descriptions are based on that locality.

Lower member. The Lower member is further divisible into three, distinct, lithological subdivisions. The lowest division (Units 1-48) consists of light to medium green-grey, in part conglomeratic sandstone interbedded with maroon shale and minor caliche. The rock types are arranged in distinct, fining-upward cycles (Fig. 10); shale conglomerate and coarse or very coarse grained sandstone form the base over an abrupt contact, in places a channelled surface, and grade in the middle part of the cycle to very fine grained sandstone. In the lower and middle parts of the cycles, crossbedding is common and consists mostly of planar, low-angle foresets with a mean set thickness of 0.3 m; maximum thickness is 0.5 m. Trough crossbedding and ripple marks are rare. Desiccation cracks were observed in one instance (Unit 15). The upper parts of the cycles, not always present, comprise maroon siltstone, maroon silty shale, and minor silty limestone. Some of the shale is calcareous; the calcareous content decreases in the higher parts of the division. The ratio of sandstone to finer grained rock types varies throughout the lower division of the Lower member. In the lower part, more fine grained rock types than sandstone are present, whereas in the upper part the ratio is about 1:1. The thickness of individual cycles is also variable. Complete cycles are in the order of 4 m thick, with a maximum of 14 m (Units 24-31). The lower division is unfossiliferous.

The middle division of the Lower member of the Okse Bay Formation (Units 49-71) consists of mostly medium grained, light grey sandstone interbedded with minor maroon, silty shale, conglomerate and fine or coarse grained sandstone. In contrast to the underlying division,

Upper
ATION

Figure 9. Dark (maroon) coloured (Lower member) and light coloured (Upper member) strata of the Okse Bay Formation are overlain unconformably by Nansen Formation strata. Elevation difference from base of cliff to base of Nansen Formation is approximately 700 m. North side of de Vries Glacier. ISPG photo. 2525-20.

Figure 10. Fining-upward cycles, consisting of light coloured, crossbedded, conglomeratic sandstone in the lower part, and maroon, fine grained sandstone in the upper part, form part of the Lower member of the Okse Bay Formation. Section A, Units 46-48, Yelverton Pass. ISPG photo. 2525-19.

shale and siltstone form less than 10 per cent of the interval. Caliche is absent. The various rock types are generally arranged in fining-upward sequences with conglomeratic and coarse grained sandstone at the base. Thickness of the cycles is variable, with a maximum of 23 m (Units 52-55). Channel fills at the bases of beds or cycles are common. Planar crossbedding is present. The thickness of sets is quite variable, with a mean of about 0.5 m. The greatest observed thickness is 1 m. Fossils are extremely rare. At the base of Unit 49, a small bone fragment was found.

The upper division of the Lower member (Units 72-77) is poorly exposed. It consists of dark green and maroon, silty shale, interbedded with sandy siltstone and sandstone. The siltstone is dark brown-grey, very thin bedded, and contains a large number of plant fragments and some coal laminae. The sandstone is medium grained and massive.

Main constituents of the sandstone in the Lower member are quartz and chert grains. Other constituents (rock fragments, feldspars, phyllosilicates and heavy minerals) are rare, and rarely exceed a combined total of 5 per cent in the analyzed specimens. Two varieties of chert are present in about equal proportions. One is very fine crystalline, sometimes associated with chalcedonic spherulites; the other is aphanocrystalline and impure. Frequently, a textural alignment is present in the aphanocrystalline variety. The chert is gradational to siliceous shale. Total chert percentage increases upward through the lower and middle divisions from less than 10 per cent in the lower part of the section to 40 to 50 per cent in the middle division. Carbonate cement is present mostly in the lower division. In the terminology of Pettijohn (1975), the sandstones are sublitharenites and lithic arenites.

Upper member. The Upper member of the Okse Bay Formation consists of interbedded sandy conglomerate, conglomeratic coarse grained sandstone, and medium grained sandstone. Siltstone and shale are present, but they are exceedingly rare and form discontinuous lenses and partings along major bedding planes. In some intervals the rock types are arranged as fining-upward cycles, about 4 to 5 m thick. The most common structures after horizontal bedding are planar, low-angle crossbeds. The thickest observed cycle is 1.5 m thick. The member is apparently devoid of fossils.

Composition of the Upper member is similar to the middle division of the Lower member. Chert, again two types, forms close to 30 per cent of the rock, while quartz amounts to about 70 per cent. Other constituents (rock fragments, feldspars, etc.) are absent or form less than 1 per cent of the rock.

The contact between the two members of the Okse Bay Formation is abrupt but probably conformable. Combined measurements of the azimuths of crossbeds for both members indicate a northwesterly flow direction.

Mode of origin. The lower division of the Lower member is dominated by fining-upward cycles, which are interpreted as point bar sequences of a meandering river. They are commonly complete, from channel lag conglomerates at the base to shaly and calcareous floodplain deposits at the top. The middle division also contains fining-upward cycles, although not as distinct and complete as those of the lower division. Possibly these are also point bar deposits, but the muddy component of the sediment load in this case must have been much less than that of the lower division. The apparent absence of large-scale inclined bedding indicating lateral accretion may suggest a sandy, braided river. The upper division contains predominantly shaly sediments with some coal and sandstone, suggesting backswamp deposits with occasional crevasse splay sands. The conglomerates and sandstones of the Upper member represent braided stream deposits with elements of Scott and Donjek type rivers (Miall, 1981). Characteristic of Scott type rivers are the massive conglomerate and conglomeratic sandstone, whereas the cyclical and crossbedded, more sandy intervals indicate Donjek type rivers.

The source area of the sediments is to the southeast, toward the Grantland Mountains and the Hazen Plateau. The abundance of chert grains and chert pebbles in the Okse Bay Formation suggests that the Cambrian to Silurian Hazen Formation (Trettin, 1971) was a major contributor of material. Structural studies by Maurel (1989), combined with the present directional data, imply a small, Devonian subbasin and a source on the northern flank of the Grantland Anticlinorium. This anticlinorium was situated online with the present Osborne and Garfield ranges (see Figure 2 for the location of these mountain ranges near the head of Tanquary Fiord).

Age and correlation. Two samples from the Lower member (GSC locs. C-45307, C-70282) and one from the Upper member (GSC loc. C-70283) yielded palynomorphs (Appendix 3b). The indicated age is Devonian, with a tentative range from late Givetian to Frasnian. This age range encompasses the Okse Bay Group and the lowest part of the Parry Island Formation on southern Ellesmere Island, where the Okse Bay Group consists of five alternating red shaly and white sandstone formations, similar to the Lower and Upper members of the Okse Bay Formation in the project area. If a simple one-to-one correlation of the two northern members with two southern formations exists at all, it is not possible to say which two formations are equivalent to the two members.

Emma Fiord Formation

Definition. The Emma Fiord Formation was used by Thorsteinsson (1974) to define a carbonaceous siltstone unit of Viséan age. It is about 350 m thick at the type section on northwestern Ellesmere Island, where it unconformably overlies folded lower Paleozoic rocks; it is in turn overlain disconformably by the Borup Fiord Formation.

Distribution, nomenclature, thickness, and contact relationships. The Emma Fiord Formation is present in three areas: one small outcrop area near the head of Clements Markham Inlet (Field Station 46), reported previously by Christie (1964, p. 34) as an unnamed unit; in the large nunatak at the head of M'Clintock Glacier (Field Station 22); and in the vicinity of Parker Bay and Cape Hecla. Emma Fiord rocks in this area were part of the "Sail Harbour group", an informal reconnaissance term which has now become obsolete. The outcrop areas of the Emma Fiord Formation are aligned along the axis of Sverdrup Basin.

After Feilden and de Rance (1878), Blackadar was the first geologist to map the area between Alert and Markham Fiord. He subdivided the succession into 10 informal reconnaissance units which he called "groups" (Blackadar, 1954), although not in the sense of formal stratigraphic nomenclature. According to Blackadar (1954, p. 12) the "Sail Harbour group" consisted of black shale, slate, and argillaceous limestone, and showed different degrees of deformation. Christie (1964) retained the term "Sail Harbour group", but slightly modified the outcrop areas mapped by Blackadar. Mapping associated with the present report (Mayr et al., 1982a) shows that the "Sail Harbour group" includes a number of different formations. The lower Paleozoic Lands Lokk and the Imina formations probably account for the slates and strongly folded rocks noted by Blackadar. Sverdrup Basin strata of the "Sail Harbour group" are the horizontally bedded limestones and siltstones on Parry Peninsula and southwest of Parker Bay, now assigned to the Emma Fiord Formation, and strongly folded evaporitic shales that belong to the Otto Fiord Formation. The Emma Fiord Formation has the widest extent within the area originally mapped as "Sail Harbour group".

Preserved thickness of the Emma Fiord Formation at Clements Markham Inlet is 50 m; at M'Clintock Glacier the beds are folded and faulted and exceed 60 m in thickness. Minimum estimated thickness in the Parker Bay area is in the order of 700 m. The lower boundary is an angular unconformity at M'Clintock Glacier and at Clements Markham Inlet. In the Parker Bay area, the lower boundary is not exposed, but the formation is essentially flat lying and only slightly faulted, whereas the Lands Lokk and Imina formations, separated by faults from the Emma Fiord Formation, are intensely folded. The upper boundary of the Emma Fiord Formation is a disconformity with the Borup Fiord Formation.

Lithology. Two lithofacies assemblages can be distinguished: a noncalcareous assemblage present in the two western outcrops, and similar to that of the type section of the Emma Fiord Formation; and a calcareous lithofacies, which is present around Parker Bay and was part of the former Sail Harbour group.

Several short, incomplete sections from the lower part of the noncalcareous assemblage were examined at the M'Clintock nunatak (Field Station 22; Fig. 30). There the formation rests with angular unconformity on lower Paleozoic volcanic units. The base is formed by about 15 m of conglomerate. The conglomerate is massive or very thick bedded and very poorly sorted. Maximum pebble diameter is 10 cm. Pebbles consist of chert, quartz and sandstone. In the upper part, the conglomerate unit contains lenses of medium to coarse grained quartzarenite. Channel-fill deposits are present in the lower part.

The basal conglomerate unit is overlain by a poorly exposed sequence of interbedded dark coloured sandstone, siltstone, shale, and minor conglomerate. The sandstones are immature and exhibit variable composition and texture. They range from very fine grained, lithic greywacke to coarse grained sublitharenite. Almost all of the rock-derived component is chert. Much of the matrix is chlorite. The siltstone and sandstone are dark grey and very thin bedded. The grains are angular and poorly sorted. The siltstone is micaceous and has a chloritic matrix. XRD analysis (Appendix 4) shows a chlorite component of up to 22 per cent. The shale is very dark grey and occurs as thin interbeds. Poorly preserved plant fossils are present in the shale and siltstone.

About 50 m of the Emma Fiord Formation are exposed at Clements Markham Inlet, and were examined only briefly. The exposure consists of a number of fining-upward cycles, comprising at the base coarse grained sublitharenite, and grading upward into laminated, very fine grained lithic greywacke and dark, slaty shale. Abundant plant fragments are present in the exposed succession.

The calcareous lithofacies (Figs. 11, 12) near Parker Bay consists of interbedded siltstone and lithic arenite, with lesser shale and limestone. Lithic wackes are rare. The sandstone is fine to very fine grained; the non-quartz component is predominantly chert. Some of the sandstone has calcareous cement and contains carbonate intraclasts and skeletal fragments. Laminae of increased carbonate content are present, and, in some instances, the calcareous sandstone grades to sandy limestone. The sandstone and siltstone are thin to very thin bedded and display ripple marks, load casts, small trough-crossbeds and burrows.

The limestones are packstones and grainstones (Dunham, 1962) composed of skeletal fragments, predominantly ostracodes or coated grains with cores of dasycladacean fragments, crinoid fragments or intraclasts. Uncoated intraclasts are also common. The limestone is thin bedded and is variably silty or sandy.

Mode of origin. The two facies assemblages are derived from two distinctly different environmental settings. The noncalcareous facies, containing carbonaceous material and locally abundant plant fossils, is of nonmarine origin. Information is too sparse for a detailed interpretation; fining-upward cycles may be of point bar origin.

Ostracodes, coated grains and dasycladaceans in the calcareous facies indicate a shallow marine environment. The sparseness of fossils other than ostracodes suggests brackish water conditions. The predominantly fine grained terrigenous components of the rocks indicate deposition in a low energy, sheltered environment. These conditions are all present in the deeper parts of a coastal lagoon in a relatively humid climate. The limestone interbeds probably formed during times of normal marine circulation, with the coated grains and carbonate intraclasts washed in from a coastal barrier during storms.

Age and correlation. Christie (1964, p. 34) reported Lower Carboniferous plant fossils from the noncalcareous lithofacies assemblages at the outcrop southwest of Clements Markham Inlet. Elsewhere in northwestern Ellesmere Island, a Viséan age has been determined for the Emma Fiord Formation (Thorsteinsson, 1974). The calcareous lithofacies yielded a single conodont sample from the top of Section B (GSC loc. C-99616, Appendix 3b) of late Viséan or early Namurian age. It is impossible to determine from available evidence whether the two lithofacies assemblages of the Emma Fiord Formation are correlative with each other; possibly they are even two different formations. If they were not deposited in individual basins separated by space and time, they might have been part of a river system that flowed into a coastal lagoon to the northeast. The three outcrop areas are aligned along the axis of Sverdrup Basin, and the Emma Fiord Formation represents the initial sediments of the incipient basin.

Figure 11. Calcareous lithofacies of the Emma Fiord Formation, forming cliffs in the Parker Bay area. Top of cliff is about 400 m above sea ice. Section B was measured in central gully (crossed hammers). ISPG photo. 2525-22.

UPPER CARBONIFEROUS AND LOWER PERMIAN FORMATIONS

Formations of the marginal belts

Canyon Fiord Formation

Definition and history. Along the eastern and southern edges of Sverdrup Basin, from Ellesmere Island to Melville Island, the redbeds of the Canyon Fiord Formation overlie folded lower Paleozoic rocks with angular unconformity and constitute the lowest unit of the Sverdrup Basin along its margin.

The Canyon Fiord Formation was named originally by Troelsen (1950) for "gray impure, highly fossiliferous limestone overlain by gray sandstone" near Caledonian Bay on the northeast side of Canyon Fiord. In the same publication, Troelsen also proposed the "Greely Fiord group", which overlies folded lower Paleozoic rocks with angular unconformity. The lowest two divisions of the "Greely Fiord group" consisted of grey, reddish weathering fossiliferous limestone and of yellow, crossbedded sandstone with conglomerate layers. Thorsteinsson (1974) examined the type area of the Canyon Fiord Formation in considerable detail, and found that the lowest two divisions of the "Greely Fiord group" are, in fact, correlative with the Canyon Fiord Formation. He recommended that the term "Greely Fiord group" be abandoned. Further, he concluded that Troelsen's (1950) type section contains only part of the Canyon Fiord Formation and established a number of reference sections to cover the complete formation. He redefined the Canyon Fiord Formation as a unit of redbeds along the margins of Sverdrup Basin, which overlies rocks of the Franklinian Geosyncline with angular unconformity and is overlain gradationally by either the carbonates of the Belcher Channel Formation or by a succession of three formations: the Antoinette, Mount Bayley, and Tanquary formations, equivalent to the Belcher Channel Formation. The Canyon Fiord Formation is generally Moscovian (Thorsteinsson, 1974)

Figure 12. Calcareous lithofacies of the Emma Fiord Formation, consisting of interbedded, variably calcareous, thin to medium bedded siltstone. Section C, Cape Hecla. ISPG photo. 2525-23.

in age, but in the type area and along the extreme eastern margin of Sverdrup Basin in central Ellesmere Island, the formation is as young as Sakmarian, and forms an eastern terrigenous equivalent of the Belcher Channel limestone.

In the present report area, the Canyon Fiord Formation is present in the southeastern and northwestern marginal belts. A cross-section by Feilden and de Rance (1878) across Feilden Peninsula (Figure 13 of the present report) shows three units: folded "Cape-Rawson beds" overlain with angular unconformity by the "Dana-Bay Beds", which in turn are overlain conformably by the "Carboniferous Limestone". According to that cross-section, the Dana-Bay Beds form the oldest unit of the post-Silurian succession, a position that corresponds to the Canyon Fiord Formation in modern terminology. Feilden and de Rance (1878) gave no lithological description of the Dana-Bay Beds; they considered them to be of Devonian age and once alluded briefly to possibly correlative red sandstone in Greenland. The cross-section can only be positioned approximately on modern geological maps, but it is reasonably certain (see also Blackadar, 1954) that the "type area" of the Dana-Bay Beds is along the south side of the Porter Bay Fault Zone at Porter Bay, in outcrops now assigned to the Assistance Formation (Mayr et al., 1982a). Structure in this area is very complex and outcrops are poor and discontinuous; local dip reversals are present. Incomplete structural information probably caused Feilden and de Rance (1878) to place these Assistance Formation rocks below what is now considered to be Belcher Channel Formation (Table 2). Blackadar (1954) re-examined the Dana-Bay Beds, collected Upper Carboniferous and Lower Permian faunas from them and noted their structural complication. He also concluded, erroneously

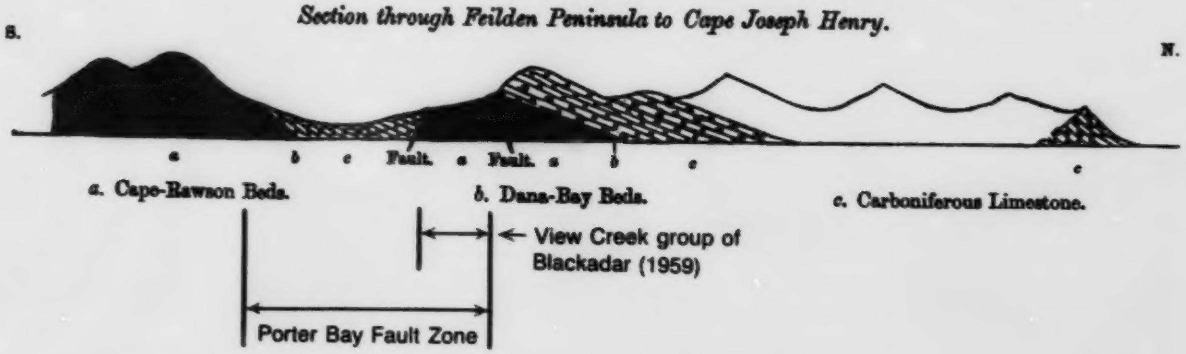

Section through Feilden Peninsula to Cape Joseph Henry.
S.
N.
a
b
c
Fault.
a
Fault.
a
b
c
c
a. Cape-Rawson Beds.
b. Dana-Bay Beds.
c. Carboniferous Limestone.
View Creek group of Blackadar (1959)
Porter Bay Fault Zone

Figure 13. Cross-section through Feilden Peninsula by Feilden and de Rance (1878). This is the first geological interpretation from northern Ellesmere Island and correctly shows the important unconformity between the lower Paleozoic basement and the overlying Carboniferous sequence. Structure in the Porter Bay Fault Zone is more complex than shown on the cross-section and this has led to misinterpretation of the stratigraphic sequence (see Table 2).

however, that they were older than the less deformed Guide Hill and Feilden "groups" (informal terms) in the surrounding area. Blackadar (1954) also described some slightly metamorphosed beds, which he called "View Creek groups". He assumed that they underlay his "Dana Bay group" with structural continuity, and for that reason he assigned a Permian or older age to them. The "View Creek group" is located on the north side of the Porter Bay Fault Zone, in an area of poor outcrop and structural complexity. These rocks are now assigned to the Silurian Lands Lokk Formation (Mayr et al., 1982a). The "Guide Hill group" (Blackadar, 1954) was described as "chocolate-red sandstone and conglomerate, brick-red sandstone, black and purple shale, and grey limestone." The conglomerates and sandstones of the "Guide Hill group" are now considered to belong to the Canyon Fiord Formation, and the shales and limestones, which are restricted to the area around Parker Bay, have been assigned to the Borup Fiord Formation.

Elsewhere in the southeastern marginal belt, the presence of Canyon Fiord Formation in the Henrietta Nesmith Glacier area was noted by Christie (1964), and Nassichuk (1967). The formation also has been described in the area around the head of Tanquary Fiord (Nassichuk and Christie, 1969). The presence of Canyon Fiord Formation in the northwestern marginal belt was reported first by Nassichuk (1967). Later Trettin (1969a) published a detailed description of Carboniferous sandstone and limestone (Map unit 10 of Trettin) from the head of M'Clintock Inlet. These rocks are now assigned to the Canyon Fiord Formation.

Distribution, thickness, and contact relationships. In the southeastern belt, the formation is present in the area between the head of Tanquary Fiord and Feilden Peninsula and thickens gradually toward the northeast. In the Tanquary Fiord area, thickness is variable and ranges from a feather edge to about 210 m at Field Station 1 near Redrock Creek (Fig. 14). At Henrietta Nesmith Glacier, it is about 260 m thick (Davies and Nassichuk, in press), at Clements Markham River (Section K, Figs. 6, 15) the thickness is estimated at 250 to 300 m, and on Feilden Peninsula (Christie, pers. comm., 1987) the thickness is 440 m or more.

In the northwestern marginal belt, the formation is present at the head of M'Clintock Inlet, at the west side of Disraeli Fiord, and south of the head of Markham Fiord. At M'Clintock Inlet it is about 1000 m thick. Near

TABLE 2

History of stratigraphic nomenclature for Feilden Peninsula and Parker Bay area

SYSTEM		PRESENT NOMENCLATURE	FEILDEN AND DE RANCE (1878)		BLACKADAR (1954)	
			STRATIGRAPHIC SUCCESSION AS PUBLISHED	CORRELATED SUCCESSION	STRATIGRAPHIC SUCCESSION AS PUBLISHED	CORRELATED SUCCESSION
PERMIAN	UPPER					
	LOWER	ASSISTANCE FORMATION		DANA BAY BEDS	FEILDEN GROUP	DANA BAY GROUP
		BELCHER CHANNEL FORMATION		CARBONIFEROUS LIMESTONE	GUIDE HILL GROUP DANA BAY GROUP	FEILDEN GROUP
CARBONIFEROUS	UPPER	CANYON FIORD FORMATION	CARBONIFEROUS LIMESTONE		VIEW CREEK GROUP	GUIDE HILL GROUP [1]
	LOWER	EMMA FIORD FORMATION			SAIL HARBOUR GROUP	SAIL HARBOUR GROUP [2]
DEVONIAN			DANA BAY BEDS			
SILURIAN AND OLDER		VARIOUS FORMATIONS	CAPE RAWSON BEDS	CAPE RAWSON BEDS	CAPE RAWSON GROUP	CAPE RAWSON GROUP VIEW CREEK GROUP

Note: 1. Includes Borup Fiord Formation. 2. Includes minor lower Paleozoic units.

Markham Fiord the thickness is 927 m (Figs. 15, 16, in pocket). At Disraeli Fiord, exposure is very poor, and the formation was not examined there.

The formation rests with angular unconformity on a variety of folded lower Paleozoic units. The upper boundary with the Belcher Channel, Mount Bayley or Antoinette formations is conformable. The boundary is marked by a change from dominantly reddish sandstone beds below to mainly greyish carbonate beds above. Commonly, this colour change is sharp, but the presence of interbedded carbonate and sandstone below and above the contact, and the absence of any physical evidence of an unconformity at this level indicate that the contact is gradational.

Lithology. Southeastern marginal belt: at the head of Tanquary Fiord (Field Station 1, Fig. 14) the typical lithofacies consists mainly of maroon, coarse and very coarse grained, conglomeratic sandstone; pebbles are up to 3.5 cm in diameter. It is thick bedded with minor, medium thick beds. Sedimentary structures are abundant and include channel cuts and fills, aligned pebbles, current parting lineation, and minor crossbedding and desiccation cracks. In the upper part, the sandstone is interbedded with limestone. At Clements Markham River (Section K) the lower part of the formation consists of fining-upward cycles about six to eight metres thick. The lower parts of the cycles consist of thick bedded, conglomeratic, coarse grained sandstone. The upper parts of the cycles comprise medium grained sandstone grading to silty shale. The upper part of the section contains fewer

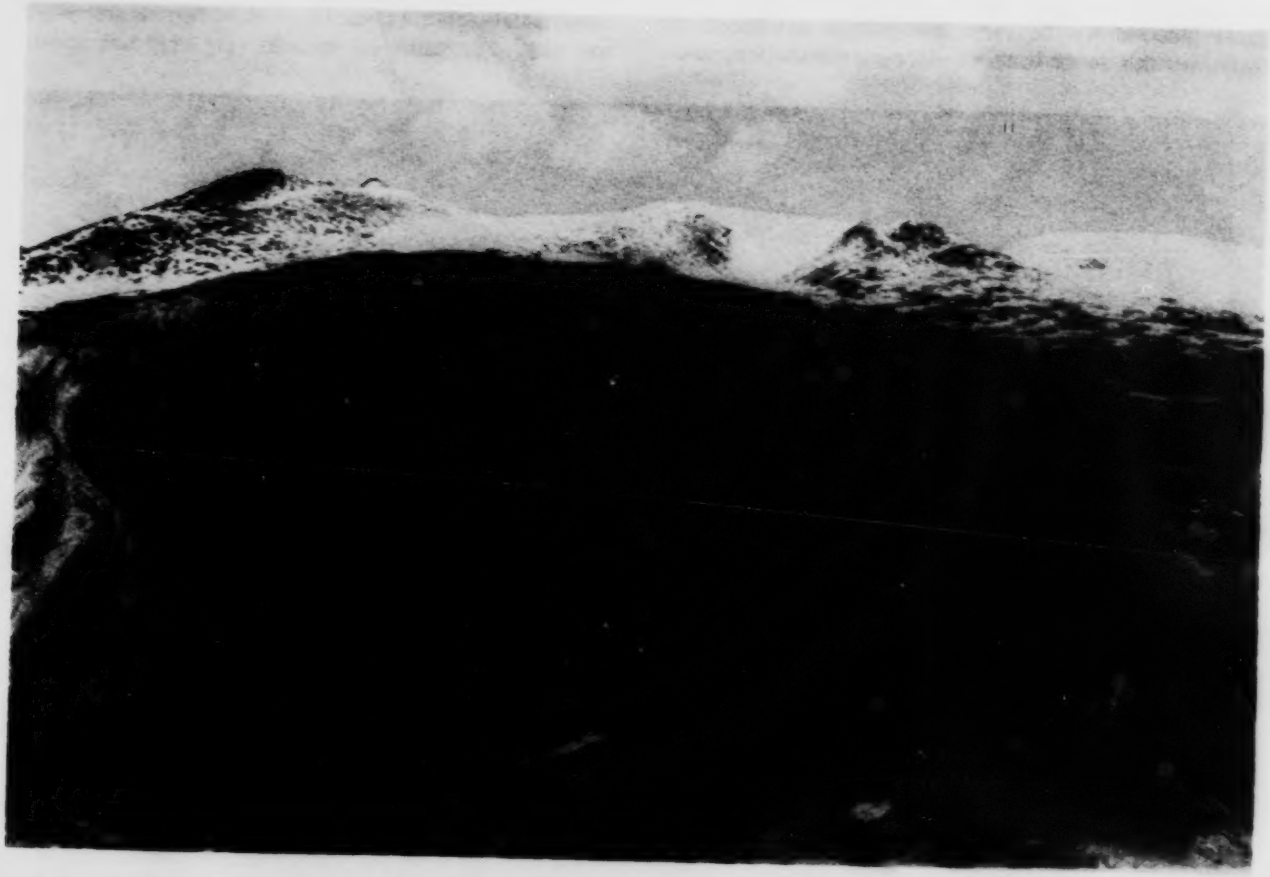


Figure 14. Strata of the Canyon Fiord Formation unconformably overlying lower Paleozoic basement rocks and conformably overlain by the Belcher Channel Formation. Limestone beds are present in the upper part of the Canyon Fiord Formation and this contact is gradational as far as the ratio of sandstone to limestone is concerned. However, the contact is marked by a sharp colour change from maroon to light grey. Field Station 1 near the head of Tanquary Fiord. ISPG photo. 2525-14.

well defined cycles and includes massive conglomerates and medium and coarse grained sandstone and minor shale.

The section on Feilden Peninsula (Christie, pers. comm., 1987) is dominated in the lower 310 m by red weathering conglomerate, with cobbles up to 20 cm in diameter. The upper 130 m of the formation consist of sandstone, ranging from fine to coarse grained to conglomeratic. Crossbedding and channel structures are evident. The section at Henrietta Nesmith Glacier was given only a cursory examination, but, at this locality, the Canyon Fiord Formation appears to contain more limestone and shaly intervals than at the three localities discussed above.

The sandstones are mostly lithic arenites; sublitharenites are less common. Grains are generally angular, and sorting is variable. At Clements Markham River (Section K) the very fine grained sandstone is schistose; this is an area of strong deformation, and thrust and overturned beds are present. The lithic component of the sandstone consists of fragments of chert, siliceous siltstone and shale, weathered volcanic rock fragments, and rare, medium crystalline dolomite fragments. Feldspars are estimated to make up less than 1 per cent of the rock. Phosphate is present in several sandstone samples collected from the Tanquary Fiord area.

The limestone interbedded in the upper part of the Canyon Fiord Formation is similar to that of the overlying Belcher Channel Formation. Bedding thickness is variable but ranges mostly from thin to medium. Nodular and flaser bedding were also observed at some localities. At the head of Tanquary Fiord, the limestones are skeletal grainstones, generally in the calcarenite size range. Clasts consist of crinoid and foraminifer fragments, whereas brachiopod and ostracode fragments are less common. Algal fragments are ubiquitous and vary widely in abundance (Fig. 17). The limestones are sandy and silty.

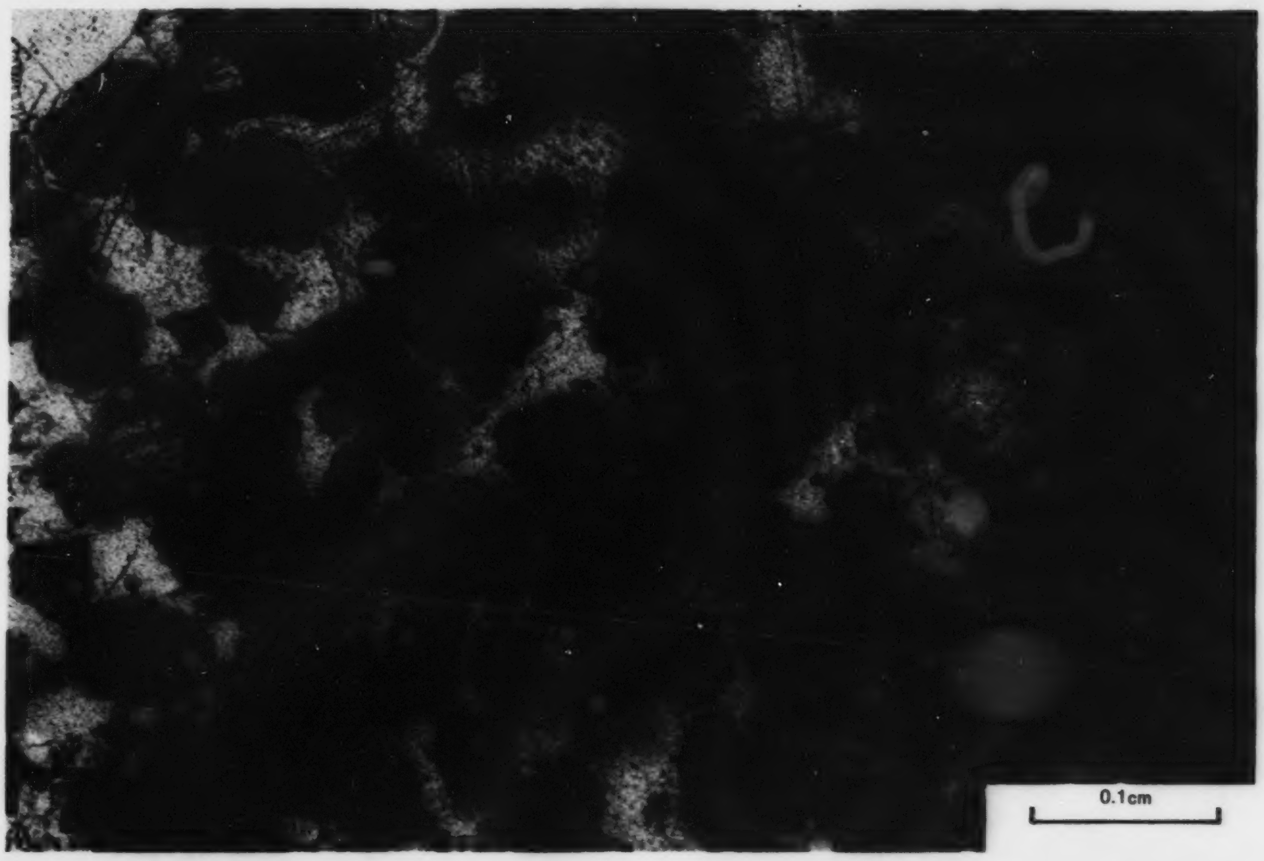


Figure 17. Photomicrograph of well sorted skeletal grainstone. Clasts consist mostly of large foraminifers (dark), codiacean fragments (coarse pattern), and crinoidal fragments (light grey, very fine pattern). The sample is from the upper part of the Canyon Fiord Formation at Field Station 2 (GSC loc. C-95137). ISPG photo. 1244 – 1.

Northwestern marginal belt: the Canyon Fiord Formation in the northwestern marginal belt is similar in lithology and outcrop appearance to that of the southeastern marginal belt. Most of it consists of the conglomerate-sandstone lithofacies typical of the formation. The typical lithofacies forms the lower 550 m or so of the formation at Markham Fiord (Section N), and is about 230 m thick at M'Clintock Inlet (Trettin's Subunit 10A, 1969a). Also included in the lithofacies is Trettin's Subunit 10C (1969a). At M'Clintock Inlet, sandstone and conglomerate form 90 per cent of the lower subunit (10A). Subordinate rock types are shaly limestone, calcareous shale, limestone, and dolomite. The sandstone and conglomerate are commonly cross-stratified. Maximum clast size of the conglomerate is 45 cm, but most clasts do not exceed 7 cm. The upper occurrence (Subunit 10C) is finer grained overall. Fine to very fine grained sandstone forms about two thirds of the subunit. One third is composed of medium to coarse grained sandstone and fine-pebble conglomerate. Subordinate lithic types are calcareous siltstone and light grey siltstone and shale.

At the head of Markham Fiord, exposure is intermittent. The dominant rock type of the conglomerate-sandstone lithofacies (Section N, Units 9–40) appears to be fine and medium grained sandstone. The sandstone is mostly maroon and variably thin to thick bedded. This sandstone is interbedded with conglomerate and coarse grained, conglomeratic sandstone. These two rock types form about 20 per cent of the total section. The conglomerates are thick bedded. Maximum pebble diameter is in the order of 10 cm (Fig. 18). Large trough-crossbeds are present in some of the conglomerate units. The conglomeratic sandstone is mostly thick bedded. Internal structures are large trough and planar crossbeds. Also present in the section are several intervals of maroon and green, calcareous, silty shale. These rock types are presumed to account for most of the covered intervals.

In composition, the sandstones of the typical lithofacies can be classified as sublitharenites and lithic arenites. They are generally moderately well sorted. The

Figure 18. Medium to thick bedded, crossbedded cobble conglomerate of the Canyon Fiord Formation. Ice-axe for scale; Unit 30 of Section N. ISPG photo. 972–77.

nature and amount of different clasts vary greatly from sample to sample, probably reflecting the availability of clasts from different exposed lower Paleozoic formations. Sedimentary rock fragments like siltstone, shale, limestone and chert appear to predominate, but, in some samples the amount of weathered metamorphic rock fragments is relatively high. Feldspars, which are generally below an estimated 1 per cent in the southeastern belt, may account for up to 5 per cent of the rock volume in the Markham Fiord section (mostly K-feldspar), and tourmaline is also a conspicuous constituent. In the Markham Fiord area, the amount of chert is less than that in the southern area. An increase in chlorite aggregates was noted in the north.

As well as the conglomerate–sandstone lithofacies, two more, different lithofacies are present in the Canyon Fiord Formation in the northwestern marginal belt: an impure limestone lithofacies, and a sandstone lithofacies. The impure limestone lithofacies is represented by Trettin's Subunit 10B (1969a) and by Units 41–47 in the Markham Fiord section (Section N). At M'Clintock Inlet, the lithofacies is about 340 m thick and consists of argillaceous limestone interbedded with calcareous shale and siltstone. Red weathering units do not form the majority of the succession. The thickness at Markham Inlet is similar (about 390 m); here, the lithofacies overlies the conglomerate–sandstone sequence with a sharp contact and is tentatively assigned to the upper part of the Canyon Fiord Formation. Calcareous sandstone, with interbeds of sandy limestone, dominates the succession. The sandstone is yellow quartzarenite with minor chert and K-feldspar. It varies from coarse grained, or conglomeratic, to fine grained. *Zoophycos* sp. occurs on bedding planes. The limestone is light grey, medium bedded and consists in part of skeletal wackestone with crinoid and brachiopod fragments. The calcareous sandstone consists of fine grained sandstone with about 50 per cent micrite matrix. The quartz grains are subrounded and well sorted. Orthoclase, chert, rock fragments, and mica form less than 10 per cent of the constituents.

The sandstone lithofacies is present only at the head of M'Clintock Inlet, where it constitutes Trettin's (1969) Subunit 10D and forms the upper part of the formation (Fig. 19). The unit is at least 450 m thick and consists mostly of varicoloured, very fine to fine grained sandstone. These beds are very thin bedded or laminated and some strata contain large ripple marks, and discontinuous beds or small troughs. Impure limestone, siltstone, shale and evaporites form subordinate components of the subunit. Directional measurements by Trettin (1969a) in the M'Clintock Inlet area, and field observations during this project in the Markham Fiord area, indicate a northerly and northwesterly source for the Canyon Fiord Formation in the northwestern marginal belt.

Mode of origin. The Canyon Fiord Formation is a transgressive sequence, deposited in environments ranging from nonmarine in the lower part to shallow marine in the upper part. Most of the lower part of the formation can be interpreted as having been deposited in a fluvial environment. Channelling, coarse grain size and abundant basal conglomerates of single beds, interbedded conglomerates, the general paucity of finer sandstone, siltstone and shale, and the lack of fossils, indicate braided or relatively fast flowing rivers. Some fining-upward cycles are present, but definite, repetitive point bar sequences, indicative of meandering streams, were not observed. Christie (pers. comm., 1987) reported a conglomeratic sequence from Feilden Peninsula, which may represent a Scott type braided river (Miall, 1981), but in the Clements Markham and Tanquary sections, massive conglomeratic sandstone, in some instances displaying rip-up clasts and desiccation cracks, predominates in the succession and implies a Bijou Creek type (Miall, 1981) river system.

Fine grained or shaly sediments are rare in the southeastern belt, particularly in the nonmarine to marine transition zone; thus, extensive flood plains or deltas were not developed during deposition of the Canyon Fiord Formation. A possible reason for this may be that, in the south, the upper Paleozoic shoreline was dominated by cliffs, and the processes at the shoreline were mainly erosional. This may also account for the presence of terrigenous conglomerate beds within the limestones, possibly derived from marine conglomerates on a pebbly beach. Also, the large amount of relatively coarse grained terrigenous material in some of the limestone beds, and the winnowed nature of the limestones themselves, can be explained as the result of a storm prone, precipitous coastline, where waves winnowed out the fine calcareous and terrigenous components, and rip-currents carried the eroded coastal material into the areas where shallow marine carbonates were being deposited.

The Canyon Fiord Formation in the northwestern belt appears to contain a relatively higher amount of siltstone and shale, indicating a larger suspended load, and floodplain areas more extensive than along the southeastern margin. Interbedded limestone and evaporite in the sandstone lithofacies imply a marine origin for the sandstone, and the laminae and large ripples indicate foreshore and shoreface sands; thus, the beach areas and lower reaches of the rivers appear to have been more extensive in the northwestern marginal belt than in the southeastern belt.

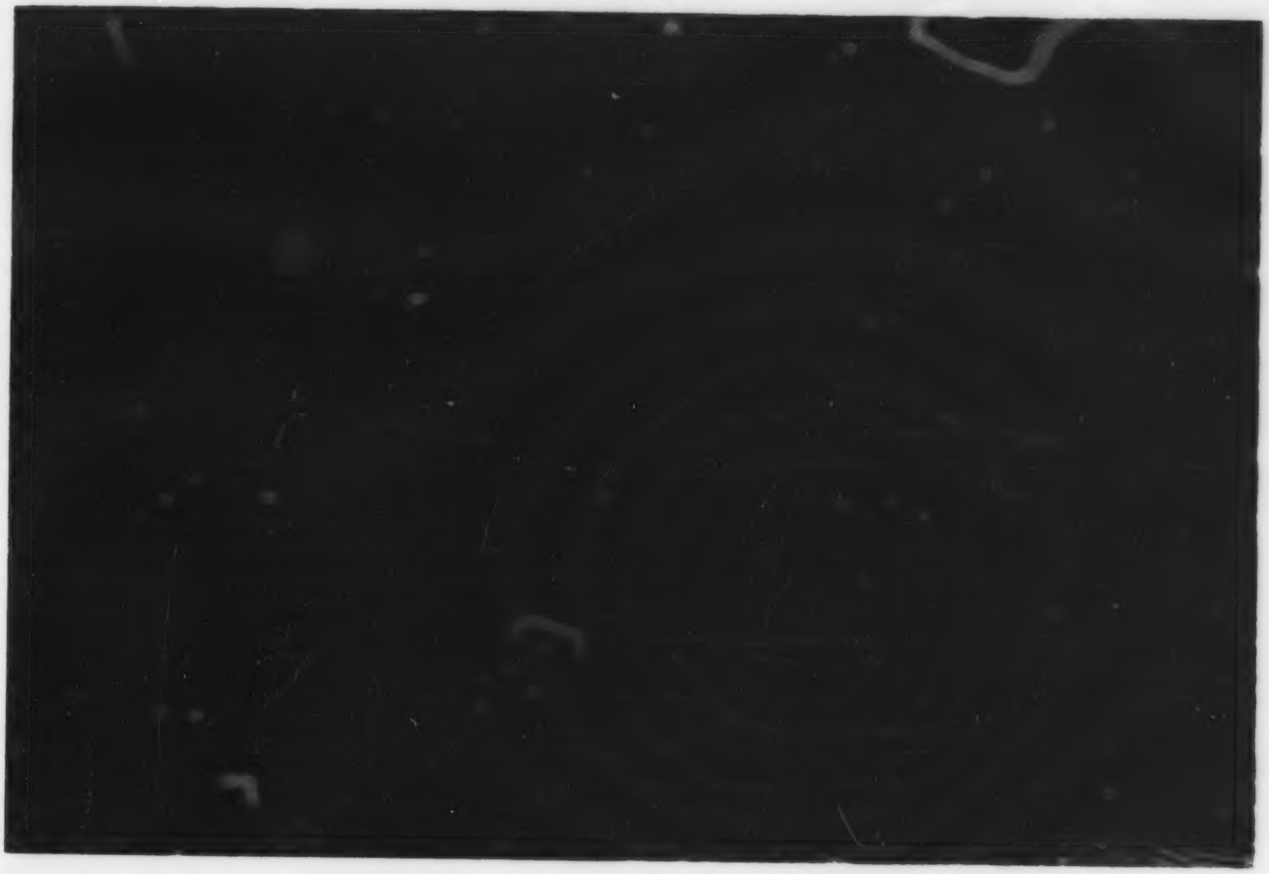


Figure 19. Sandstone lithofacies of the Canyon Fiord Formation in the northwestern marginal belt. The formation consists of thin bedded, medium grained, well sorted sandstone. Conglomerate is absent. Field Station 56 near M'Clintock Inlet. ISPG photo. 2525-16.

The northern and northwestern source directions for the northwestern belt pose some problems. The Cape Nares carbonate belt to the north of the Canyon Fiord Formation contains carbonate rocks (Nansen Formation) deposited at the same time as the fluvial sediments to the south; thus, this area does not constitute the source area. Possible explanations are a local source area on central Marvin Peninsula, perhaps an island area in the Moscovian ocean, or, alternatively, Tertiary strike-slip movements along the Parr Bay Fault that would subsequently have brought the Nansen Formation in from the southeast where the formation is fully developed. This last possibility is preferred because it agrees with the concept of a dextral shift of Svalbard from a position north of Greenland, during spreading along Nansen Ridge and the opening of the Arctic Ocean (Christie, 1979).

Age and correlation. Not many fossils of biostratigraphic value have been recovered from the Canyon Fiord Formation on northern Ellesmere Island. Trettin (1969) reported a number of plant fossils, palynomorphs, and foraminifers that indicate a general Middle Pennsylvanian (Moscovian) age. During the present study, middle Moscovian fusulinids were found in the formation at Henrietta Nesmith Glacier (GSC loc. C-69854, Appendix 3). At Clements Markham River, late Moscovian fusulinids (GSC loc. C-70316) are present in the lowest part of the Antoinette Formation. At Field Station 2, south of MacDonald River, early Gzhelian fusulinids (GSC loc. C-45135) were found in the basal part of the Belcher Channel Formation. Thus, over most of the area, the Canyon Fiord Formation appears to be Moscovian in age, although along the extreme southern edge of the project area, it may be as young as Gzhelian.

No direct evidence of a lower age limit is available from the sections examined. Thorsteinsson (1974) reported the oldest documented age as Bashkirian; generally though, the formation is entirely of Moscovian age.

Belcher Channel Formation

Definition. The Belcher Channel Formation was originally defined by Harker and Thorsteinsson (1960) on northern Grinnell Peninsula. They described the formation as consists of three units. Unit 1 (6-60 m thick), the lowest unit, consists of conglomerate; Unit 2 (43 m thick), comprises green and red sandstone; and Unit 3 (150 m thick), the uppermost unit of the Belcher Channel Formation, consists of light coloured limestone in the lower part with only minor amounts of sandy limestone and calcareous sandstone, and sandy, bioclastic limestone in the upper part. Units 1 and 2 were included tentatively in the formation. The Belcher Channel Formation at the type section is overlain disconformably by the Assistance Formation.

In 1965, Nassichuk redefined the formation, and restricted the term Belcher Channel to Unit 3 of the original definition, reassigning Units 1 and 2 to the Canyon Fiord Formation. A detailed biostratigraphic and lithological log of the formation in the type area was given by Nassichuk and Davies (1975). In that log, the lower part of the formation is dominated by calcareous, fossiliferous sandstone, the middle part by resistant, sandy and bioclastic limestone, and the upper part by interbedded calcareous sandstone and sandy limestone. Presumably, the lower sandstone unit should be assigned to the Canyon Fiord Formation (Nassichuk, 1965; Beauchamp, 1987), but the important point is the existence of an upper, sandy and recessive part in the Belcher Channel Formation as defined at that time.

Thorsteinsson (1974) pointed out that, on Bjorne Peninsula, a formation of Artinskian age might exist that is older than the Assistance Formation, but is not a part of the Belcher Channel Formation. Subsequent work (Nassichuk and Wilde, 1977) and restudy of the Belcher Channel type section (Beauchamp and Henderson, pers. comm., 1987) has shown that there is indeed a mappable unit of calcareous sandstone and sandy limestone, as yet unnamed. This unnamed formation has been variously included in the Belcher Channel, Assistance, and other formations, and corresponds to all or most of the upper, sandy part of Thorsteinsson's (1974) Unit 3 and Nassichuk and Davies' (1975) upper part of the type section of the Belcher Channel Formation. The new formation has not been formally defined yet and, in the present report, the term Belcher Channel will be used in the sense of Thorsteinsson (1974). However, the correct Artinskian correlations will be pointed out wherever known.

The Canyon Fiord Formation and the overlying carbonate sequence of the marginal belt contain evaporite lenses in central (Thorsteinsson, 1974) and northern Ellesmere Island. The evaporites in the Canyon Fiord Formation are localized and do not warrant formational names; the evaporites interbedded with the carbonates are more widespread and are distinguished by nomenclature. Where the carbonate section is complete, the term Belcher Channel Formation is used. Where an evaporite sequence is present, carbonates below the evaporites belong to the Antoinette Formation, and carbonates above the evaporites to the Tanquary Formation. The evaporites themselves are called Mount Bayley Formation (Thorsteinsson, 1974).

In the southeastern marginal belt the "Carboniferous Limestone" of Feilden and de Rance (1878) on Feilden Peninsula is the first mention of rocks now assigned to the Belcher Channel Formation, but the "Carboniferous Limestone" also includes rocks belonging to the Assistance Formation. Blackadar's (1954) informal term "Feilden group" similarly refers to rocks of the Belcher Channel and Assistance formations. Christie (1964) used Blackadar's terminology on Feilden Peninsula, but he also mapped unnamed Permo-Carboniferous carbonate rocks near Henrietta Nesmith Glacier. These carbonates are now assigned to the Belcher Channel Formation. Nassichuk and Christie (1969) gave a brief description of the formation in the Tanquary Fiord area as a unit consisting of fossiliferous limestone with minor calcareous sandstone. In the northwestern belt, carbonate rocks, here assigned to the Belcher Channel Formation, were first reported by Christie (1957) and were later examined by Nassichuk (1967). Nassichuk assigned the redbeds to the Canyon Fiord Formation, but he left the carbonates unnamed.

Distribution, thickness, and contact relationships. Exposures of the Belcher Channel Formation in the southeastern marginal belts are concentrated near the head of Tanquary Fiord, in the upper reaches of Henrietta Nesmith Glacier, and in the Feilden Peninsula–Parker River area. Measured thicknesses are variable —maximum thickness exceeds 600 m at Henrietta Nesmith Glacier (Fig. 20); at the head of Tanquary Fiord and at Parker River, the thicknesses are in the order of 150 m and 400 m, respectively. This wide variation in thickness reflects the influence of the Tanquary Structural High at the head of Tanquary Fiord, and proximal and distal positions on the shelf in the two other locations.

At Henrietta Nesmith Glacier and at Parker River, the lower contact with the Canyon Fiord Formation was not observed. At Tanquary Fiord this contact is gradational. Limestone and sandstone conglomerates are interbedded and the contact is drawn above the highest conglomerate. This coincides with a sharp change of rock colour from maroon and dark red below to grey-green above. On Feilden Peninsula, the contact is similarly gradational (R.L. Christie, pers. comm., 1987).

The upper boundary was examined at the head of Tanquary Fiord, at Henrietta Nesmith Glacier, and at Parker River. At the first two locations, the Belcher Channel Formation is overlain sharply and disconformably by the sandstone of the Sabine Bay Formation. At Parker River, the Belcher Channel Formation is overlain by dark coloured chert and shale of the lower part of the Assistance Formation. The actual contact is not exposed but appears to be sharp and without interbedding.

In the northwestern marginal belt, the Belcher Channel Formation is present in small outliers on the northwest side of Clements Markham Inlet and in a larger area on the west side of Markham Fiord (Fig. 21). Formation assignments for both locations are somewhat tentative, and with more complete biostratigraphic information, these carbonates, mostly in incomplete sections, might be assigned to the Nansen Formation. Exposed thickness at Markham Fiord is estimated as 500 m. The base of the formation was not seen there.

Lithology. The Belcher Channel Formation comprises, in decreasing order of importance, resistant, relatively thick

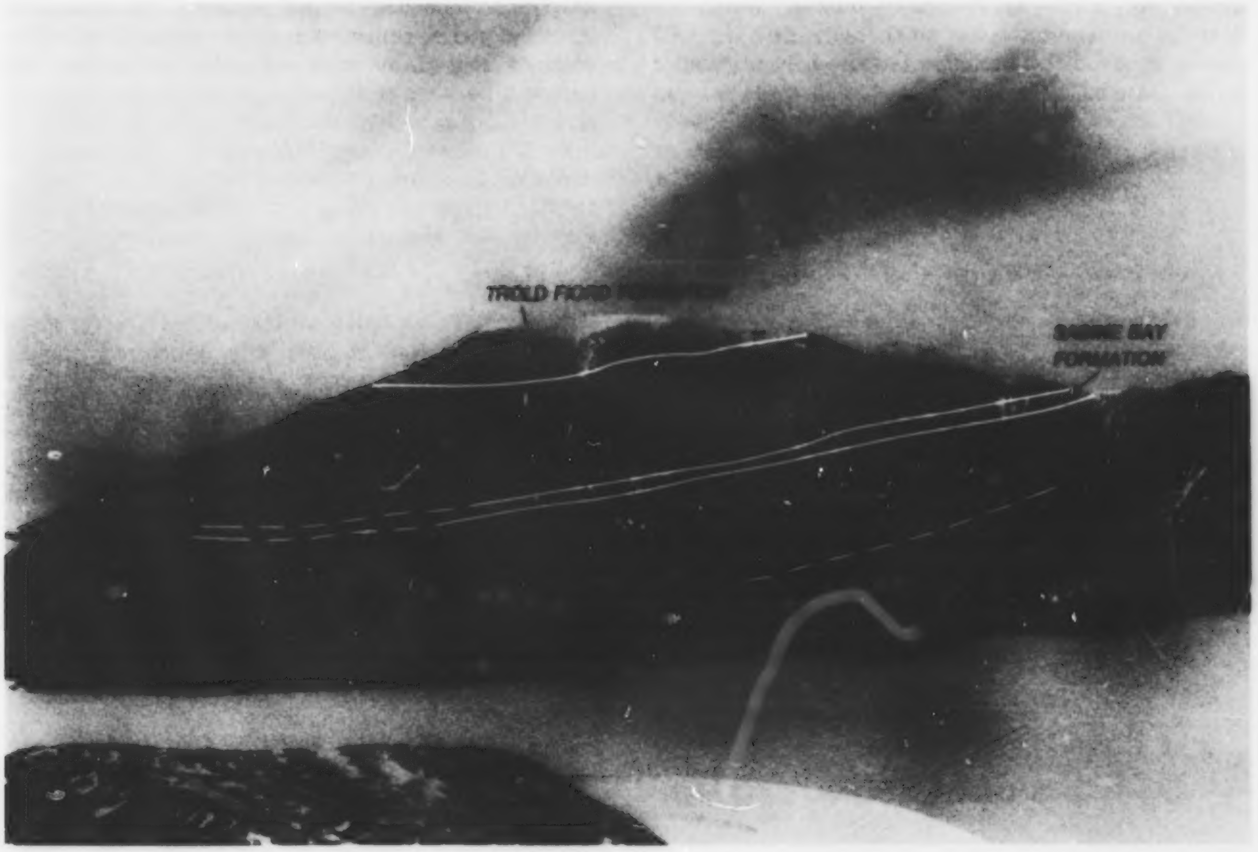


Figure 20. Sequence of the Belcher Channel, Sabine Bay, Assistance and Trold Fiord formations at the upper part of Henrietta Nesmith Glacier. The Belcher Channel Formation consists mostly of resistant, thick or medium bedded limestone. The prominent recessive interval in the upper third of the Belcher Channel Formation probably marks the base (dashed line) of the unnamed formation of Nassichuk and Wilde (1977). Upper part of Section D was measured in the central ravine (crossed hammers). ISPG photo. 972-5.

bedded limestone, and recessive, thinner bedded siltstone, sandstone, sandy and silty limestone, and chert. The limestone and siltstone-sandstone are interbedded in intervals several tens to hundreds of metres thick.

The resistant limestone assemblage comprises grainstone and packstone and is mostly thick to medium bedded, but massive and thin bedded intervals are also locally present. Colour varies from medium to dark grey and brown. Clast size ranges from medium calcarenite to coarse calcirudite grade. The composition of clasts is variable. Crinoid fragments, pelletoids and fragments of calcareous algae are the most common grain types. The pelletoids are mostly associated with the fine calcarenite, while the echinoderm and algal fragments are more abundant in the medium calcarenite. Foraminifera, other than fusulinids, and ostracodes are ubiquitous. Mamet and Roux (1982) listed the content of one sample (GSC loc. C-45488) from the lower part of the formation at Macdonald River (Field Station 3). Fragments of macrofossils besides echinoderms are present overall, but are subordinate. However, locally, bryozoans may be rock forming. Sorting of the clasts is very variable and the rocks range from well sorted and rounded carbonate grainstones to muddy, poorly sorted types. Noncarbonate grains consist of quartz and chert and occur in small amounts (<5%) throughout the limestone. In rare instances, they may form up to an estimated 20 per cent of the rock volume. Chert nodules and occasional silicification of matrix are present throughout the sections.

The second major lithological assemblage comprises calcareous and dolomitic, fine or very fine grained sandstone and siltstone, interbedded with silty limestone. Composition of the sandstone is variable. Recrystallized dolomite and calcite grains can account for up to 20 per cent of the content. Other nonquartz constituents such as

Figure 21. Resistant, medium and thick bedded limestone of the Belcher Channel Formation, overlain by shale and redbeds of the Assistance Formation. The cliff is about 300 m high. Crossed hammers indicate location of upper part of Section F. West side of Markham Fiord. ISPG photo. 2525-4.

feldspar or clay minerals are rare. Mica is virtually absent. Most sandstones are well sorted and have a mosaic texture. The silty limestone and calcareous siltstone are gradational into each other. Skeletal fragments occur throughout. Some samples are notable for well preserved calcispheres.

Dolomite is rare in the Belcher Channel Formation. A very slightly silty, aphanocrystalline variety is present in the upper part of the formation at Field Station 3 near the head of Tanquary Fiord. It is light coloured and exhibits fine laminae and possible bioturbation features.

The Belcher Channel Formation is profusely fossiliferous. Corals and brachiopods occur throughout the formation, but are particularly concentrated in some shaly beds. Most obvious corals are large specimens of *Bothrophyllum* sp. Small foraminifers, *Tuberitina* sp., *Apterinella* sp., and *Tetrataxis* sp., for example, occur throughout the formation, whereas abundant occurrences of fusulinids appear to be restricted to certain horizons. Echinoderms and calcareous algae are the most common skeletal material. The algal fragments are mostly derived from codiacean, including phylloid, algae; second in abundance are dasycladacean fragments. The silty interval in Section D at Henrietta Nesmith Glacier is rich in *Zoophycos* sp. Algal grains in the silty-sandy facies are derived from dasycladaceans, codiaceans, and phylloid algae.

Mode of origin. The skeletal limestone of the Belcher Channel Formation is of shallow marine, above wave base, origin. The relatively large amount of sand in the limestone indicates proximity to shore. Recent codiacean and dasycladacean algae flourish at depths of less than 25 m (Wray, 1977) and the same is presumed to hold true for Permo-Pennsylvanian species. Calculations by Draper (1967) for points around England show that wave induced water speeds, high enough to winnow fine grained sand for more than 300 days of the year, are restricted to depths shallower than 25 m for close to shore areas. The interbedded, finer detrital sediments may represent deposition in deeper water than that in which the skeletal limestone was deposited. Nassichuk and Davies (1975) and Beauchamp (1987) interpreted the Belcher Channel Formation on Grinnell Peninsula and central Ellesmere Island in terms of shallowing-upward sedimentary cycles. Similar cycles can be recognized in the present study area (for example Units 8 to 10 in Section D), but no systematic study of this phenomenon was undertaken during the present investigation.

Age and correlation. Near the head of Tanquary Fiord, the age range of the formation is from Moscovian to early Sakmarian (GSC locs. C-45119 and C-45499, respectively; Appendix 3); at Henrietta Nesmith Glacier, the age range of the examined portion (Section D) is from Asselian to early Artinskian (GSC locs. C-69867 and C-69894, respectively; Appendix 3). Fossils from the Parker River section cannot be dated more accurately than Early Permian.

The age range of the Belcher Channel Formation (Thorsteinsson, 1974) in the type section is from Asselian to early Artinskian; elsewhere the formation has been dated as old as Late Carboniferous.

The part of the Belcher Channel Formation that corresponds to the unnamed new formation is latest Sakmarian and early Artinskian in age (Nassichuk and Wilde, 1977). Equivalents of the unnamed formation appear to be absent in the Tanquary Fiord area, presumably as a result of pre-Sabine Bay erosion. In the Henrietta Nesmith Glacier area, the upper part of the Belcher Channel Formation is equivalent to the unnamed formation. A stratigraphic break within the Belcher Channel Formation, from massive limestone below to thinner bedded, recessive limestone above, is present between Units 23 and 24 of Section D. The break falls at about the Sakmarian-Artinskian boundary, and Units 24 to 35 probably correlate with the new, unnamed formation (Fig. 20).

Antoinette Formation

Definition. The name Antoinette Formation was proposed by Thorsteinsson (1974) for "a formation consisting mainly of dark grey, impure limestone with varying proportions of siltstone, sandstone, shale and anhydrite." The type section is at Greely Fiord. The formation is underlain by the Canyon Fiord Formation and overlain by the evaporites of the Mount Bayley Formation. The Antoinette Formation is about 470 m thick, and is the stratigraphically lowest formation of a succession of three formations, which are lateral equivalents of the Belcher Channel Formation. These are, in ascending order, the Antoinette, Mount Bayley, and Tanquary formations. The Mount Bayley Formation consists of anhydrite, whereas the Antoinette and Tanquary formations are lithologically similar to the Belcher Channel Formation. The distinction between the two formations and the Belcher Channel Formation is arbitrary and is based on the presence of the intervening evaporite formation.

Distribution, thickness, and contact relationships. The Antoinette Formation occurs only in the southeastern marginal belt in the Clements Markham River area (Section K) where it is about 320 m thick. The lower boundary is gradational and was drawn above the highest maroon and brown sandstone and siltstone. The upper boundary is sharp and is placed below the lowest evaporite solution breccia of the overlying Mount Bayley Formation.

Lithology. The Antoinette Formation consists predominantly of dark and medium grey, variably bedded dolomite. The lower part of the formation is gradational with the Canyon Fiord Formation and consists of interbedded sandy dolomite and dolomitic sandstone. The dolomite is mostly medium crystalline, dark coloured and thick bedded with minor medium beds. Boundaries between the dolomite and sandstone beds are sharp. The sandstone is medium grained, has dolomite cement and is generally thin bedded. Its composition is immature and variable, but sublitharenite appears to be the most common sandstone type. Internal planar, parallel bedding, and lamination are present but no other sedimentary structures were seen.

The dolomite in the upper part ranges from silty and thin bedded, to relatively pure, thick bedded units. It is variably fine and medium crystalline. Relict grains are present as coated grains and fossil fragments. Some relict textures indicate skeletal grainstone.

Mode of origin. The depositional environment of the Antoinette Formation is probably similar to that of the Belcher Channel Formation; that is, a shallow marine setting in proximity to shoreline. Planar, parallel bedding and lamination of sands are common in a beach setting (Reineck and Singh, 1973), and the relict textures in the dolomite indicate a well winnowed, shallow marine environment.

Age and correlation. A late Moscovian foraminiferal fauna (GSC loc. C-70316, Appendix 3) was recovered from the lower part of the formation. As the overlying Mount Bayley Formation is also of late Moscovian age, the age of the entire Antoinette Formation is late Moscovian. Thorsteinsson (1974) reported a general age range from Zhigulevian or Orenburgian (Late Carboniferous) to Asselian, although in one instance he encountered rocks as old as Moscovian. Thus, although there is some age overlap between the Antoinette Formation at Clements Markham River and the formation farther south, most of it on northern Ellesmere Island is older than on central Ellesmere Island.

Mount Bayley Formation

Definition. Thorsteinsson (1974) proposed the name Mount Bayley Formation for an anhydrite-gypsum sequence exposed at Greely Fiord. Maximum thickness of the formation is about 240 m. The formation overlies the Antoinette Formation and is present on Hamilton and Fosheim peninsulas and on the north side of Greely Fiord. It is overlain by the limestone of the Tanquary Formation. The Antoinette, Mount Bayley and Tanquary formations correlate with the Belcher Channel Formation and are distinguished by the intervening evaporites of the Mount Bayley Formation. Trettin's (1969) map Units 11 and 12 at M'Clintock Inlet, consisting of evaporite and breccia, have been assigned here to the Mount Bayley Formation. Nassichuk (1967) mentioned the presence of evaporites between Markham Fiord and M'Clintock Inlet, and Christie (1964) mapped evaporite occurrences near Gypsum River on the north side of Clements Markham Inlet. These evaporites belong to the Mount Bayley Formation.

Distribution, thickness, and contact relationships. In the southeastern marginal belt, the Mount Bayley Formation is present only at Clements Markham River (Section K). There the formation is at least 720 m thick, including 75 m of volcanic rocks. The lower boundary is sharp and was drawn below the lowest occurrence of evaporite solution breccia. The upper boundary is not exposed and the upper part of the formation is cut off by the Crescent Glacier Fault, which places Otto Fiord Formation above Mount Bayley Formation.

In the northwestern marginal belt, the formation is exposed at M'Clintock Inlet and at the head of Markham Fiord. At Markham Fiord the formation is faulted and internally folded — a tentative thickness estimate would be 400 m or more. At M'Clintock Inlet, the thickness is estimated to be about 400 m. Smaller areas of outcrop of Mount Bayley Formation consist of evaporites exposed at Gypsum River on the northwest side of Clements Markham Inlet. The thickness there was not determined, but is probably within the regional range of several hundred metres.

At M'Clintock Inlet, the lower boundary with the Canyon Fiord Formation is conformable; at Markham Fiord this boundary is a fault. The upper boundary is also conformable, and, in the case of the solution breccia at M'Clintock Inlet, gradational with the overlying bedded Tanquary Formation.

Lithology. In the northwestern marginal belt, the Mount Bayley Formation comprises evaporites and evaporite solution breccia. The evaporite lithofacies consists mostly of anhydrite (Fig. 22). The anhydrite is thick bedded, displays internal lamination, and is interbedded with very dark grey, laminated lime mudstone. Solution breccias are associated with the evaporites throughout the area and are usually situated as discontinuous lenses between the evaporites and adjacent carbonates. The breccia is

Figure 22. Light coloured anhydrite of the Mount Bayley Formation (left side of photograph) overlying the sandstone facies of the Canyon Fiord Formation with sharp contact. The slope in the right foreground consists of talus from solution breccia of the Mount Bayley Formation. Field Station 56 (Fig. 19) is situated on crest of far ridge, just above the base of the fog. Head of M'Clintock Inlet. ISPG photo. 2525–13.

massive and weathers bright yellow. It consists entirely of limestone clasts, which are angular to subrounded and very poorly sorted. Maximum observed diameter is 5 cm. Clast types vary from lime mudstone to skeletal packstone.

At Clements Markham River (Section K), in the southeastern marginal belt, the formation consists of breccia and interbedded silty dolomite. The breccia beds overlie the dolomite units with sharp contact, but the contact between the breccia beds and overlying dolomite is in many instances gradational. The breccia beds are massive, and generally less than 10 m thick, but greater thicknesses (up to 30 m) have been observed. No internal sedimentary structures were seen. Clast diameter varies greatly; the largest seen was 10 cm. The material of the clasts is fine and very fine crystalline, slightly silty dolomite. Other material, mostly dark, laminated limestone, is rare, and occurs only in a few beds. Most beds are monomictic. Quartz grains are present between the dolomite clasts in some samples. In several instances, the breccia clasts themselves were fractured and cemented by dolospar, prior to inclusion in the breccia. The texture of the breccia varies. Some beds consist of fractured dolomite, the clasts being somewhat rotated though essentially in situ. At the other extreme, the dolomite clasts form a chaotic texture and the beds may contain rare, exotic pebbles. Limestone clasts derived from a bioclastic source are present in several units. They consist of skeletal grainstone and contain fragments of phylloid and other algae, brachiopods, bryozoans, and various foraminifers.

The bedded dolomite is very fine to fine crystalline and is medium to thin bedded. Individual dolomite intervals rarely exceed 5 m in thickness. Bedding is planar, and small-scale bioturbation is visible in thin section. Crossbedding occurs locally in the uppermost part of the dolomite intervals. The dolomite is silty and quartz may form up to an estimated 30 per cent of the rock. Minor constitutents are mica and various feldspars. Siliceous sponge spicules also are commonly present in the dolomite. Flat-pebble conglomerate was observed in some instances.

As well as the breccia and dolomite intervals, several beds of limestone are present in the upper part of the formation. The limestone is massive and consists of skeletal packstone and wackestone with abundant fragments of brachiopods, bryozoans, and phylloid algae.

The middle part of the formation contains 75 m of volcanic rocks (Section K). The volcanics are underlain by about 10 m of chaotic conglomerate with a maximum clast size exceeding 1.5 m. More than 50 per cent of the boulders are of volcanic material, the remainder consist of lime mudstone. The volcanics are pillow lavas interbedded with volcanic conglomerate. Composition of the flow is that of a tholeiitic basalt (see Appendix 4).

Mode of origin. The Mount Bayley Formation is an evaporitic sequence. The evaporites occur as lenses within carbonate shelf deposits of shallow, normal marine origin (Belcher Channel, Antoinette, and Tanquary formations) and possibly represent local peritidal conditions. At M'Clintock Inlet, where they directly overlie shoreline sands of the Canyon Fiord Formation and are overlain in turn by carbonates, a sabkha origin cannot be excluded. The breccias are interpreted as being evaporite solution breccias. The lack of transport, the monomictic composition, and lack of sedimentary structures support this interpretation. The interbedded dolomite at Clements Markham River has no features of subaerial exposure, but the rare, flat-pebble conglomerate and crossbedding may indicate intertidal or shallow subtidal conditions of deposition. Deposition of this facies may have been cyclical. Each cycle commenced with restricted circulation, forming interbedded dolomite and evaporites. Circulation improved gradually, evaporite deposition ceased and dolomite without evaporites was deposited. At the same time circulation of the less saline water through the immediate substratum dissolved the evaporites and caused the formation of the breccia. Causes of the fluctuations in salinity can be only speculated upon — they could be climatic changes over several years, inconsistent subsidence, or periodic breaching of a barrier.

Age and correlation. One fusulinid fauna (GSC loc. C-70258, Appendix 3) of late Moscovian age was found in the upper part of the formation. The underlying Antoinette Formation is also of Moscovian age; thus, the exposed part of the Mount Bayley Formation in the southeastern belt is entirely of Moscovian age. At M'Clintock Inlet, the formation is underlain immediately by Moscovian fusulinids (Trettin, 1969). The oldest overlying fossils found are of Early Permian age (GSC loc. C-70002, Section N; Appendix 3). Thus, the maximum age range in the northwestern marginal belt is Moscovian to Early Permian. The Mount Bayley Formation of northern Ellesmere Island does not correlate directly with the Mount Bayley Formation of the type area, where it is Early Permian in age only and consists entirely of evaporites (Thorsteinsson, 1974). However, the stratigraphic position of the evaporites and breccias appears to justify the formation assignment.

Thorsteinsson (1974, p. 41) reported an unusual section of Canyon Fiord Formation from central Ellesmere Island. In that area, the middle part of the formation contains about 60 m of anhydrite; thus, it could be argued that the evaporite and breccia of the northwestern marginal belt should be included in the Canyon Fiord Formation. However, the rocks under discussion form a distinct, mappable unit and therefore were assigned to the Mount Bayley Formation.

The Mount Bayley Formation is equivalent to the lower part of the Belcher Channel Formation and, in the Clements Markham River area, overlies rocks that can without difficulty be assigned to the Antoinette Formation.

Tanquary Formation

Definition. The Tanquary Formation is the uppermost of the triune consisting of the Antoinette, Mount Bayley, and Tanquary formations. The name was proposed by Thorsteinsson (1974) for a unit of carbonate and clastic strata, and the type section is near the mouth of Tanquary Fiord.

Distribution, thickness, and contact relationships. The formation is present only in the northwestern marginal belt. Thickness is estimated at about 500 m. The lower boundary is conformable, sharp with the evaporites, and gradational with the breccia of the Antoinette Formation. The upper contact with the Assistance and Degerböls formations is disconformable.

Lithology. The formation consists predominantly of light grey, massive or thick bedded limestone. Most of the limestone is coarse to very coarse grained skeletal packstone or grainstone. Lime mudstone is subordinate. The massive and thick bedded limestone contains several intervals of thin to very thin bedded, darker coloured limestone. This limestone is argillaceous or silty and consists of lime mudstone or skeletal wackestone. The Tanquary Formation is very fossiliferous and contains abundant corals, brachiopods, bryozoans, and other fossils.

Mode of origin. Like those of the Belcher Channel and Antoinette formations, the limestone of the Tanquary Formation originated on a shallow, normal marine shelf. The formation may contain a rhythmically alternating sequence of thin bedded argillaceous limestone and thick bedded winnowed limestone indicating shallowing-upward cycles, as shown by Nassichuk and Davies (1975) and by Beauchamp (1987) for the Belcher Channel Formation on central Ellesmere Island. However, detailed stratigraphic information to confirm the presence of this sequence is not available.

Age and correlation. The section at the head of Markham Fiord contains fossils of possible Asselian (GSC loc. C-70002, Appendix 3) and of Leonardian (GSC loc. C-70004, Appendix 3) ages. The youngest age is constrained by late Leonardian or early Wordian faunas (GSC loc. C-99547, Appendix 3), which overlie the Belcher Channel Formation about 20 km farther north at the west side of Markham Fiord. The Tanquary Formation thus has a probable age of Lower Permian (Asselian to Leonardian). The upper part of the formation is correlative with the unnamed formation of Nassichuk and Wilde (1977) but, because of discontinuous outcrops, no significant stratigraphic break was seen in the field that would confirm this correlation.

Formations of the carbonate belts

Borup Fiord Formation

Definition. Thorsteinsson (1974) used the name Borup Fiord Formation to define a series of redbeds, the type section of which is in the vicinity of Hare Fiord. At the type section, about 160 m of red sandstone, conglomerate, and minor limestone are exposed. The Borup Fiord Formation is present over large areas of northern Ellesmere and Axel Heiberg islands. It generally overlies highly deformed lower Paleozoic rocks with angular unconformity, except in a few instances where it overlies the Emma Fiord Formation with a regional disconformity. The thickness of the Borup Fiord Formation varies considerably, suggesting deposition in an active rift basin with considerable local relief. The formation is overlain conformably by either the carbonates of the Nansen Formation or evaporites of the Otto Fiord Formation. In the areas of the carbonate belt, the Borup Fiord Formation is similar in lithology to the Canyon Fiord Formation and the distinction between the two units is one of stratigraphic position rather than of differences in lithology. The Canyon Fiord is present along the edges of Sverdrup Basin and is mostly of Moscovian age; the Borup Fiord Formation occupies the central part of Sverdrup Basin and is of Serpukhovian age, considerably older than the Canyon Fiord Formation. Presumably both formations form a diachronous, continuous unit at the base of the Sverdrup Basin, but redbeds of intermediate age are rare.

On northern Ellesmere Island, the Borup Fiord Formation comprises two different lithofacies: the typical conglomerate-sandstone lithofacies is present in the carbonate belt, whereas in the basinal belt, the formation consists of shale and siltstone. The description of the shale-siltstone facies is provided in the subsection dealing with the basinal belt. The Borup Fiord Formation in the carbonate belt has been reported by Nassichuk and Christie (1969) in their section "thirteen miles north of Yelverton Lake." Another reported occurrence of red sandstone and conglomerate, "three miles north of Yelverton Lake" (Nassichuk and Christie, 1969; Mayr, 1976) is now assigned to the Okse Bay Formation.

Distribution, thickness, and contact relationships. Major occurrences of the Borup Fiord Formation in the carbonate belt are restricted to the area around the head of Yelverton Inlet. Spectacular exposures are present in the cliff at the southwest side of the unnamed peninsula between de Vries Glacier and Yelverton Inlet (Fig. 23, Section E3) where the formation is about 900 m thick. This cliff appears to be near a depocentre for the Borup Fiord Formation, because the formation thins in all directions away from there. Nassichuk and Christie (1964) reported a thickness of about 500 m in an area halfway between the head of Yelverton Inlet and Yelverton Lake. The formation is not present in the cliffs along the north side of de Vries Glacier, about 25 km to the east, nor is it present at Yelverton Pass, 35 km to the southeast or, except for a small, local wedge, in the valley toward the head of Tanquary Fiord. The formation also thins considerably to the north and west and is not present in the northwestern arm of the carbonate belt.

In the area of the carbonate belt, the lower boundary of the Borup Fiord Formation is an angular unconformity with folded lower Paleozoic rocks. The upper boundary is gradational. It was drawn below the first shale-limestone interval.

Lithology. The Borup Fiord Formation was examined in some detail at Section E3 at the head of Yelverton Inlet. Three lithological subdivisions can be distinguished. The lower division is about 100 m thick and comprises Units 1-13 in Section E3 (Appendix 2). The division consists mostly of conglomerate; interbeds of sandstone, siltstone and shale form less than 25 per cent of the succession. The conglomerate is light coloured and thick bedded to massive. Maximum pebble size is in the order of 8 cm. Medium grained sand forms the matrix. Sedimentary structures include channelled surfaces and rare, low angle, tabular crossbeds in excess of 1.5 m in thickness. The bedded sandstone is a sublitharenite and is medium to coarse grained and generally conglomeratic. Bedding thickness varies from medium to massive. The siltstone and shale form thin, discontinuous units. The conglomerate and sandstone of the lower subdivision are mature. Chert forms up to an estimated 30 per cent of the conglomerates, while altered rock fragments (up to an estimated 10 per cent) occur in the sandstone. The rock is generally quartzitic, although illite forms cement in several samples (Appendix 4).

The light coloured conglomerate of the lower division is overlain by maroon coloured conglomerate, sandstone, siltstone, and minor shale (Units 14–100, about 580 m thick) of the middle division. Siltstone forms about half of the succession. Although random sequences or multiple cycles are present, the various rock types are generally arranged in fining-upward cycles (Fig. 24). Thicknesses of the cycles vary considerably, from about 2 m to more than 30 m. Generally they start with an erosional, commonly channelled lower surface, overlain by conglomerate or sandstone. Maximum pebble size is in the order of 3 cm in the lower part of the division and increases to 8 cm in the middle part (Unit 91). The conglomerate intervals are poorly bedded or massive; crossbedding can sometimes be discerned. More commonly than conglomerate, sandstone forms the base of the cycles. The basal sandstones range from coarse to

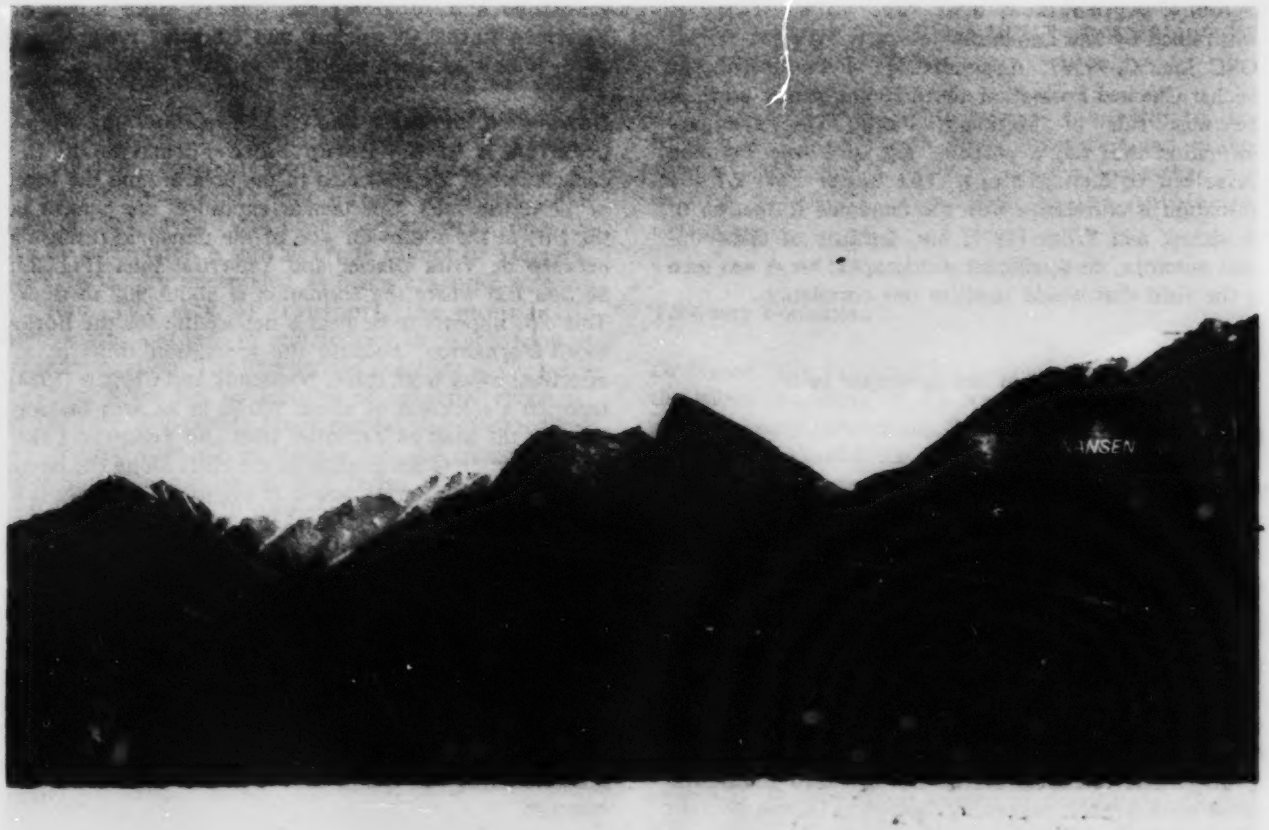


Figure 23. Conglomerate, sandstone and shale of the Borup Fiord Formation, unconformably overlying lower Paleozoic basement rocks and in turn overlain, with gradational contact, by dolomite belonging to the lower member of the Nansen Formation. Height of cliffs is about 1300 m. Lower part of Section E3 was measured in the central ravine (crossed hammers). Head of Yelverton Inlet. ISPG photo. 2525–18.

medium grained and are generally conglomeratic. They are mostly thick bedded with low angle, planar crossbeds. Trough crossbeds also are present but were observed much less frequently.

Very fine grained sandstone and siltstone form the middle parts of the cycles. The rocks are maroon, but have green laminae or mottles where they form the top of a cycle. The siltstone-sandstone units are commonly the thickest part of the cycle. The sandstone units are thin to very thin bedded, whereas the siltstone rarely exhibits any structures at all. Calcareous concretions are present in Unit 70, which forms the top of a cycle. Where the cycles are complete, the uppermost part is formed by silty shale. The shale is maroon, locally with green laminae and mottling.

The sandstones of the middle division of the Borup Fiord Formation are sublitharenites and consist of quartz and chert. Grains are generally moderately well sorted and subrounded. The amount of chert varies from less than 1 per cent to 20 per cent. Chlorite is ubiquitous and occurs in amounts up to 5 per cent. Most of it is of detrital origin, but a small amount of it occurs together with illite to form the cement of the sandstones. Rock fragments are present as a subordinate component (less than 3 per cent). Hematite occurs as cement and is responsible for the maroon colouring of the rocks.

The upper division of the Borup Fiord Formation (Units 101–121; 220 m thick) comprises maroon sandstone, interbedded with minor conglomerate and shale. The sandstone forms about 75 per cent of the succession. Most of the sandstone is fine grained and

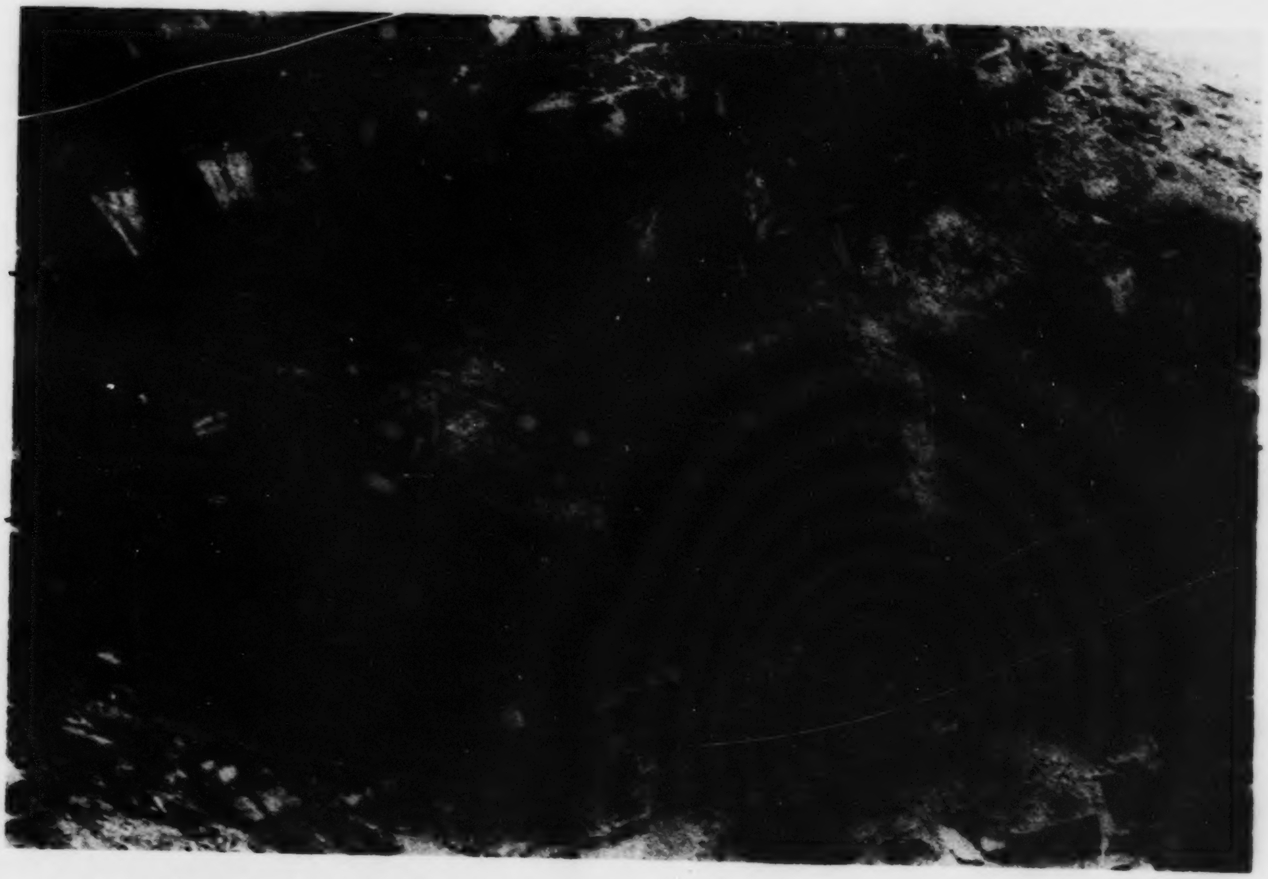


Figure 24. Fining-upward cycles in the Borup Fiord Formation. These cycles consist of crossbedded, coarse and medium grained sandstone at the base, fine grained sandstone and siltstone in the middle part, and silty shale in the upper part. Interval shown in photograph is about 10 m thick. Section E3, head of Yelverton Inlet. ISPG photo. 2525–17.

thick bedded, with well sorted and rounded grains, and, except for lamination of individual beds, does not show any sedimentary structures. The base of the upper part is formed by a massive conglomerate. Maximum pebble size is 13 cm, much larger than that of conglomerates in the middle and lower parts of the Borup Fiord Formation. Maximum pebble size of other conglomerates in the upper part is 18 cm. Most of the shale is concentrated in Unit 108, the upper part of a fining-upward cycle. The shale is maroon with green specks. It contains zones of small, calcareous concretions.

The presence of feldspar and the carbonate content distinguish the sandstones of the upper division of the Borup Fiord Formation from those of the two lower divisions. The sandstones are well sorted, subangular quartzarenites and contain up to 5 per cent feldspar, the major part of which is K-feldspar. Chert is subordinate (1 per cent or less) but the amount of mica reaches a maximum of 4 per cent. Cements are formed by illite and dolomite. As well as the chert pebbles contained in the lower two units, the upper unit contains pebbles of sandstone.

Measurements of 19 directional features, mostly direction of crossbedding, indicate a westerly source (see Figure 7 in Maurel, 1989) for the Borup Fiord Formation at Yelverton Inlet. This locality is situated near the southwestern closure of the northern basin.

A spectacular occurrence of conglomerate is present on the Tanquary Structural High. At Field Station 6, southwest of Yelverton Pass, the Borup Fiord Formation increases in thickness from a feather edge to more than 75 m within a horizontal distance of less than 200 m. The unit consists of a maroon coloured, massive boulder conglomerate (some boulders are more than 45 cm in diameter), derived directly from the underlying lower Paleozoic Imina Formation.

Mode of origin. Fining-upward cycles, channel fills, preponderance of conglomerate in parts of the section, and the absence of marine fossils mark the Borup Fiord Formation as the deposit of a fluvial system. This fluvial system filled the basin, presumably from the west, in a longitudinal direction. The only observation of current direction is from the southeastern part of the basin, where a western source is indicated. This interpretation is corroborated by the presence of a more distal shale-siltstone facies to the northeast (see the section on "Formations of the basinal belt" below).

The conglomerates of the lower division may be from the distal part of an alluvial fan; certainly they are closer to the source area than the sequence in the remaining part of the formation. The fining-upward cycles of the middle division are indicative of meandering river sediments, deposited after the basin had filled somewhat and the topography along the faulted basin margin had become subdued. A shift of the river, or perhaps renewed uplift of the source area is indicated by the conglomerates at the base of the upper division, when a new system of alluvial fans prograded over the river system of the middle division. Fining-upward sequences are rare, and the existence of a braided-river system is probably more likely during deposition of this interval.

The conglomerate present at Field Station 6 is interpreted as an alluvial fan. Boulders can almost be seen "peeling off" the jointed, lower Paleozoic Imina Formation along a paleoslope of 20° or more. The Borup Fiord Formation is, however, absent or very thin in the immediate vicinity of this location and the conglomerate fan is interpreted as an isolated patch of the formation near a small local source.

Age and correlation. No biostratigraphically significant fossils were found in the Borup Fiord Formation. The age in the project area is bracketed by the Viséan age of the underlying Emma Fiord Formation and by the Bashkirian age (GSC locs. C-45383 and C-45421, Appendix 3) of the lower part of the overlying Nansen Formation. That leaves an approximate age range of Serpukhovian and Bashkirian, similar to the Serpukhovian age of the Borup Fiord Formation described by Thorsteinsson (1974) farther southwest. Correlation with the facies in the basinal belt is not supported by biostratigraphic evidence and is based only on stratigraphic position below the Otto Fiord Formation and the paleogeographic compatibility of fluvial sediments with coastal plain sediments.

Nansen Formation

Definition. Thorsteinsson (1974) gave the name Nansen Formation to a thick limestone sequence of Bashkirian to Artinskian age that forms the carbonate belt of the Sverdrup Basin. At the type section near the head of Hare Fiord, the formation is about 2370 m thick and consists of uniformly bedded lime mudstone, interbedded with minor bioclastic limestone. Thickness at the type section appears to be maximal and the formation thins away from there in all directions. The Nansen Formation is generally underlain with gradational contact by the redbeds of the Borup Fiord Formation, and the Borup Fiord/Nansen formations form a transgressive couplet of units similar to that of the Canyon Fiord/Belcher Channel formations. The stratigraphic relationship of the Canyon Fiord/Belcher Channel couplet to the Nansen Formation has been investigated on central Ellesmere Island (Beauchamp, 1987). Beauchamp recognized three members in the Canyon Fiord Formation: a lower clastic member, a middle limestone member, and an upper clastic member. Increase of limestone content in the upper member makes this member unrecognizable and a continuous limestone succession is formed by the middle and upper members of the Canyon Fiord Formation and the Belcher Channel Formation. Beauchamp (1987) included this continuous succession in the Nansen Formation. There are no obvious independent lithological criteria to distinguish Belcher Channel carbonates from Nansen carbonates, and the lateral boundary between the two formations is arbitrary and based on stratigraphic relationships.

The unnamed formation of Nassichuk and Wilde (1977) has the same implications for the Artinskian part of the Nansen Formation as it has for the Belcher Channel Formation. However, until the unnamed formation has been defined formally, the term "Nansen Formation" will be used here in the sense of Thorsteinsson (1974). The Nansen Formation was first reported in the study area by Nassichuk and Christie (1969). However, the "sandstone beds" at their southern section ("3 miles north of Yelverton Pass") are now assigned to the Okse Bay Formation.

Distribution, thickness, and contact relationships. The Nansen Formation is best developed and exposed in the western part of the carbonate belt. In the southeastern arm of the belt, the formation is covered almost completely by the ice cap. In the northwestern arm of the carbonate belt, the formation is present in a large valley east of M'Clintock Glacier and at the head of Clements Markham Inlet.

Complete, but inaccessible sections of the formation are present at the head of Yelverton Inlet, and the formation is about 1400 m thick. It overlies the Borup Fiord Formation with gradational contact. Farther west, along de Vries Glacier, the Nansen Formation lies with slight angular unconformity directly on the Okse Bay Formation. It is overlain with sharp, presumably disconformable contact by shaly and silty carbonates assigned to the Assistance Formation. Farther south, toward Yelverton Pass, the Nansen Formation is overlain by the Trold Fiord Formation (Nassichuk and Christie, 1969). Limestones exposed in the northern part of the valley between the head of Tanquary Fiord and Yelverton Pass have also been assigned to the Nansen Formation, following the usage of Nassichuk and Christie (1969). These carbonates onlap onto the Tanquary Structural High and could, on the basis of lithology, equally well be assigned to the Belcher Channel Formation, but their age range is more akin to the Nansen Formation. These carbonates either lie directly on folded lower Paleozoic rocks or overlie gradationally very thin and discontinuous Borup Fiord Formation strata. At Yelverton Pass (Field Station 15) the upper boundary of the Nansen Formation was drawn at the contact between brecciated limestone below and a sandy limestone above that has been tentatively assigned to the Assistance Formation. The brecciated limestone at the top of the Nansen Formation is interpreted as a solution feature that formed during a time of nondeposition, or even possibly subaerial exposure. Large solution pipes and caves filled with breccia are common in the Nansen cliffs near Yelverton Inlet. The upper termination of the pipes is at the unconformable contact with the dark carbonates of the overlying Assistance Formation.

The thickness of the Nansen Formation in the southeastern arm of the carbonate belt is not known. In the northwestern belt, the thickness is estimated at more than 1000 m, and the formation rests directly on folded lower Paleozoic formations. It is overlain by the Assistance Formation, but the actual contact is not exposed.

Lithology. Two different lithofacies of the Nansen Formation can be distinguished: a limestone lithofacies, which is present to the southeast of Yelverton Pass, and at least 18 km northwest of it (Nassichuk and Christie, 1964); and a dolomite lithofacies, which is present between the unnamed peninsula between Yelverton Inlet and de Vries Glacier along the northwest side of de Vries Glacier, and extends to Clements Markham Inlet.

Limestone lithofacies. This lithofacies was examined in the valley between Yelverton Pass and Tanquary Fiord (Fig. 25) and at the pass itself. It is similar to the Belcher Channel Formation as described above. Section P (Appendix 2) can be considered representative of the limestone facies. Here the formation is 387 m thick. The section is capped by a thick sill, which in this area has preferentially intruded the shales at the base of the Triassic succession. Four subdivisions can be recognized, which are in ascending stratigraphic order: 1) basal breccia and conglomerate, 27 m thick; 2) a lower limestone unit, about 60 m thick; 3) a sandstone-dolomite unit, about 135 m thick; and 4) an upper limestone unit, about 165 m thick.

The basal clastic rocks are poorly exposed. The lowest exposed unit is a large cobble breccia, consisting of chert and fine grained sandstone clasts. The uppermost part consists of conglomeratic sandstone and pebble conglomerate.

The lower limestone unit comprises alternating skeletal grainstone and lime mudstone. The limestone is massive and thick bedded. Crinoidal fragments and micritized grains, possibly of algal origin, are the dominant grain types.

The sandstone-dolomite unit is poorly exposed. It contains a diabase sill in the lower part. Sandstone is dominant in the lower part and is of variable grain size, ranging from coarse grained and conglomeratic to very fine grained. In composition it is a uniform quartzarenite with dolomitic or calcareous cement. The upper part of the unit appears to consist mostly of sandy, medium crystalline dolomite. Several interbeds of sandy, pelletal packstone are present in the middle part of the unit.

The upper limestone unit consists to a large extent of alternating recessive and resistant units, a weathering profile that seems to be characteristic for many of the upper Paleozoic carbonates of Ellesmere Island. The units form couplets 10 to 15 m thick. The recessive units are poorly exposed. They consist of somewhat argillaceous, resedimented dolosiltite. The dolosiltite is thin bedded and weathers maroon. The resistant units comprise massive limestone, sandy, skeletal grainstone, or pelletal grainstone. The uppermost part of the upper limestone unit consists of massive skeletal packstone with abundant large specimens of *Pseudofusulina*.

Dolomite lithofacies. This facies was examined in the area adjacent to the head of Yelverton Inlet and the lower part of de Vries Glacier, and in the northwestern belt. At de Vries Glacier, the Nansen Formation can locally be subdivided into three informal members: a lower dolomite member; a middle member of evaporites, reefs, sandstone and shale; and an upper, dolomite member. The Middle member is a tongue of lithotypes from the basinal belt, where they are assigned to the Hare and Otto

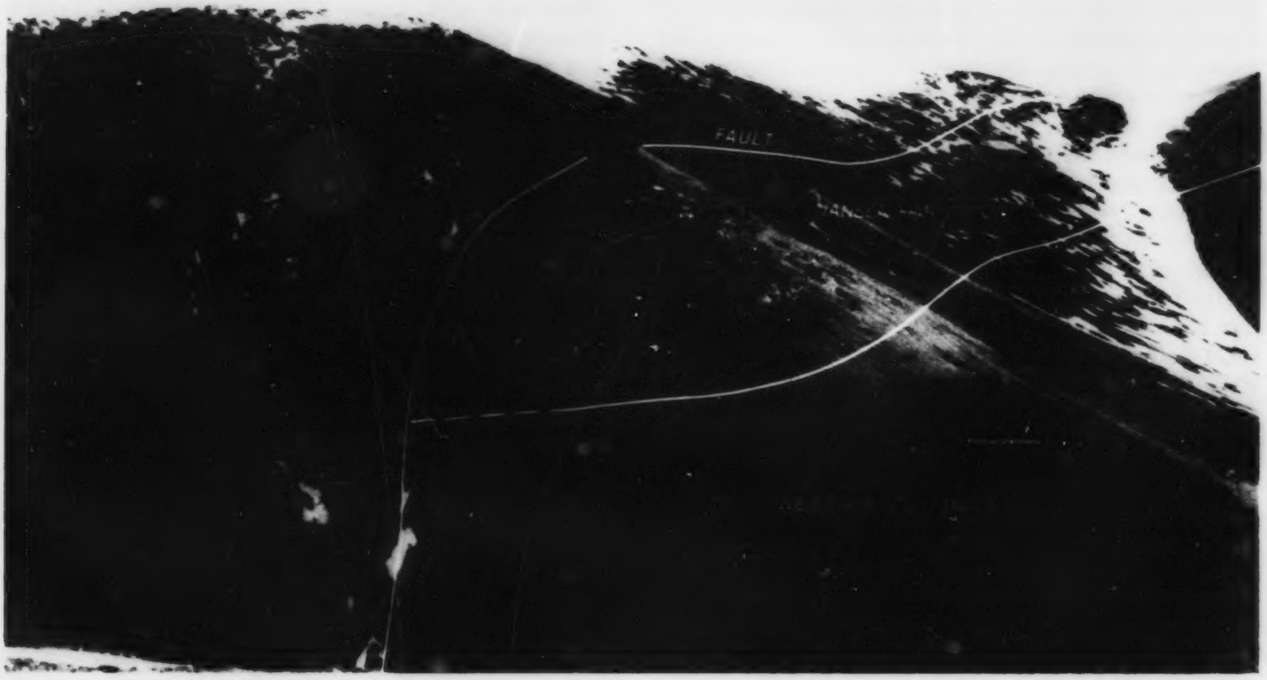


Figure 25. Limestone facies of the Nansen Formation, preserved in small fault blocks on the Yelverton Structural High. Here Nansen Formation overlies lower Paleozoic basement directly without intervening Borup Fiord Formation. The Nansen Formation consists of alternating resistant and recessive units reflecting the rhythmic nature of deposition. Preserved thickness is about 150 m. Sixteen kilometres northwest of head of Tanquary Fiord. ISPG photo. 2525-11.

Fiord formations. The Middle member appears to be discontinuous and where it is absent the upper and lower dolomite members cannot be distinguished.

Rocks assigned to the Lower member are best developed on the Yelverton Inlet side of the unnamed peninsula (Section E3) where they attain a thickness of at least 450 m (Fig. 23). Three lithological subdivisions can be recognized. The lower part of the member (Units 122–173) is 174 m thick, consists of interbedded dolomite and sandstone, and is a transition interval between the Borup Fiord sandstones and the carbonates of the Nansen Formation. The sandstones in the transition interval comprise quartzarenite and sublitharenite. In grain size and bedding characteristics they cover the spectrum from conglomeratic, fining-upward sequences to uniformly fine grained, laminated and thin bedded intervals. Some of the sandstone beds grade upward into sandy dolomite. In composition the sandstones are more mature than those of the Borup Fiord Formation. The chert component ranges from 5 to 20 per cent, but feldspars are either absent or present only in trace amounts. Cement is mostly dolomite or calcite. Transport direction, in contrast to the Borup Fiord Formation, was from the south.

The dolomite is mostly coarse crystalline. Some of it is nodular on a microscopic scale and may be bioturbated. Bird's-eye textures were also observed. Where finer textures can still be recognized, the original fabric was either pelletoidal or a coarse to very coarse grained, poorly sorted, skeletal grainstone. Grain types are very varied and include foraminifers, echinoid and brachiopod fragments, gastropod fragments, and phylloid algae.

The transition interval is overlain by a full dolomite sequence. The lower part of the dolomite sequence (Section E3, Units 174–211) is about 170 m thick and consists entirely of medium and dark grey to black dolomite. The dolomite is medium and coarse crystalline and some beds show laminar, fenestral vugs. Bedding varies from thin to thick and massive. Remnants of texture indicate an originally micritic or very fine grained pelletoidal sediment. The upper part of the dolomite sequence (Units 212–216) is in excess of 120 m thick and consists of uniformly thin bedded or massive, very dark grey, medium crystalline dolomite. In contrast to the dolomite of the underlying unit, residual texture indicates well winnowed skeletal grainstone.

The Lower member of the Nansen Formation is variably fossiliferous. In the lower and middle parts, fossil occurrences are restricted to single beds, and these are commonly argillaceous units containing abundant brachiopods. The upper part is fossiliferous throughout and contains corals, stromatoporoids, crinoids, and bryozoans.

The Middle member of the Nansen Formation varies in thickness from 300 to 400 m and consists, in ascending order, of evaporites, discontinuous bioherms, and shale and sandstone. The lower contact of the evaporites with the dolomite is gradational. The upper contact with the bioherms is also gradational and is accompanied by lateral facies changes and interfingering of biohermal rock and anhydrite. The sandstone–shale unit overlies both evaporites and reefs with a sharp disconformable contact and is in turn overlain with sharp, probably disconformable contact by the dolomite of the Upper member of the Nansen Formation.

The Middle member of the Nansen Formation was examined in Section E2. The maximum thickness of the evaporites is estimated to be about 300 m at this location, but the thickness decreases very rapidly to almost nothing less than 2 km away, where they interfinger with a large reef that sits directly on the Lower member of the Nansen Formation. The anhydrite is massive with discontinuous, internal laminae. It is interbedded with very fine and aphanocrystalline, dark coloured dolomite. The reefs have a maximum estimated thickness of 350 m and are generally inaccessible. The base of one of the smaller ones consists of crinoidal debris with lesser brachiopod fragments. These reefs are similar to the "Waulsortian" reefs described by Davis et al. (1987).

The sandstone and shale unit is about 150 m thick at the measured section, but it fills the depressions between the reefs and ranges in thickness from zero to more than 300 m. The sandstones are light grey quartzarenites or subarkoses. They are fine or medium grained and very thick bedded in the lower part of the unit. Some vague channels are present. In the upper part, interbeds of very dark grey shale are present, and grain size has decreased so that the sandstone has been replaced gradually by siltstone. The siltstone is thinly laminated and contains small channel fills of sandstone.

The Upper member of the Nansen Formation consists predominantly of dolomite. At de Vries Glacier (Fig. 26, Section E1) about 680 m are exposed. The contact between the Upper and Middle members is not exposed at Section E1, but was examined at Section E2. The contact between the underlying siltstone and shale and the overlying dolomite is very sharp and may represent a small hiatus. The lowest 10 m or so of the upper member consist of very fine crystalline, siliceous dolomite with sponge spicules, and detrital, resedimented calcisiltite interlaminated with siltstone.

In Section E1, the Upper member comprises variably siliceous, light coloured dolomite. In the lower part the dolomite is medium crystalline, in the upper part mostly fine and very fine crystalline. Bedding is thick or massive, but internal lamination is often discernible on weathered surfaces. Burrow and fenestral laminae were also seen. In the lower part of the section, intervals with lenticular bedding planes (Fig. 27) suggest algal mounds.

Two incomplete sections of Nansen Formation were examined in the northwestern carbonate belt (Section G, adjacent to the upper part of M'Clintock Glacier; and Section M, at the north side of the head of Clements Markham Inlet). At both localities, the Nansen Formation lies directly on folded lower Paleozoic rocks (Fig. 28). At M'Clintock Glacier (Section G), the lower 28 m of the Nansen Formation consist of light coloured, alternating thin and thick bedded dolomite. The lowest 5 m, directly above the basal unconformity, are very sandy. The dolomite consists of detrital dolosiltite and recrystallized calcarenite with the crystal boundaries following the original clast outlines. The lower 28 m are overlain by a 2 m thick, poorly exposed interval (Unit 8, Section G). At the base of this interval there is possibly maroon shale. Some coarse conglomerate was also observed in talus. The upper part of the interval consists of very thin bedded maroon siltstone with syneresis cracks and nodular limestone. The more than 300 m of rock overlying the siltstone consist mainly of thick bedded or massive, dark grey, hypidiotopic to xenotopic, medium crystalline dolomite. Remnants of the original texture are commonly preserved and indicate intraclast or skeletal calcarenite. Intercrystalline porosity is present. At this locality (Section G), the Nansen Formation is sparsely fossiliferous. Some brachiopods are present in the Lower member, and some corals were found in the upper portion.

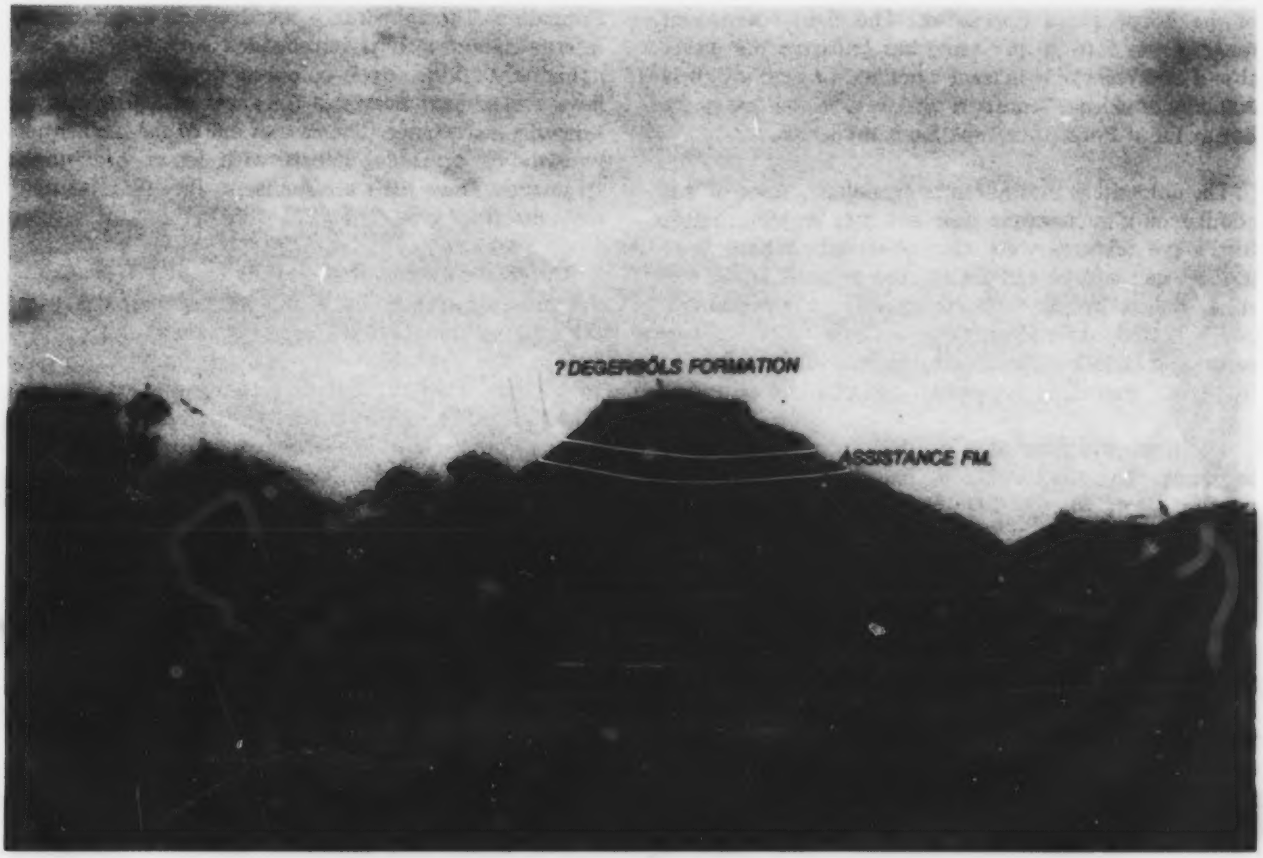


Figure 26. Massive dolomite of the Upper member of the Nansen Formation, forming steep cliffs along de Vries Glacier. This dolomite is overlain disconformably by recessive, dark, sandy limestone of the Assistance Formation. The uppermost part of the mountain consists of resistant, thick bedded limestone and chert that have been tentatively assigned to the Degerböls Formation. Section E1 (crossed hammers) was measured behind the spur at the left side of the mountain. Top of mountain is estimated to be 900 m above the glacier. ISPG photo 2525-5.

The strata exposed in the Clements Markham Inlet area are similar to those at M'Clintock Glacier. They consist of massive, mostly dark coloured dolomite with remnant skeletal grains. In addition to the bedded dolomite, a tongue evaporite and associated breccia occurs in the middle part of the succession. In the southeastern part of the carbonate belt, only one locality in the high nunataks south of M'Clintock Glacier was examined (Field Station 20). At this outcrop, the formation consists of very fine crystalline, laminated dolomite, several brecciated beds, and thin bedded lime mudstone.

Mode of origin. The two lithofacies of the Nansen Formation (limestone and dolomite) represent carbonate shelf deposits. The limestones are generally well winnowed, lack peritidal features and are interpreted as having been deposited above wave base on a shallow shelf. The cycles in the upper part are similar to the Type 2 cycles described by Beauchamp (1987) from upper Paleozoic carbonates on central Ellesmere Island. These cycles are caused by a combination of tectonic subsidence and sea-level oscillation. Type 2 cycles originated in a high energy, nearshore or shoal environment.

The dolomite lithofacies contains a variety of rock types representing environments ranging from nonmarine to submarine fan. The lower subdivision of the Lower member represents the change from a nonmarine to a marine environment. The fining-upward sandstone sequences are probably fluvial sediments, whereas the uniformly grained, laminated sands are more akin to beach sands. The interbedded dolomite contains shallow water features such as grainstone, or peritidal indicators such as bird's-eye texture. The dolomite of the middle part of the Lower member appears to contain cryptalgal features, in the form of laminar, fenestral vugs, which, together with possible pelletoidal features, indicate supra- or intertidal conditions. The well winnowed grainstones and abundant corals, stromatoporoids and other fossils reflect deepening and open marine conditions.

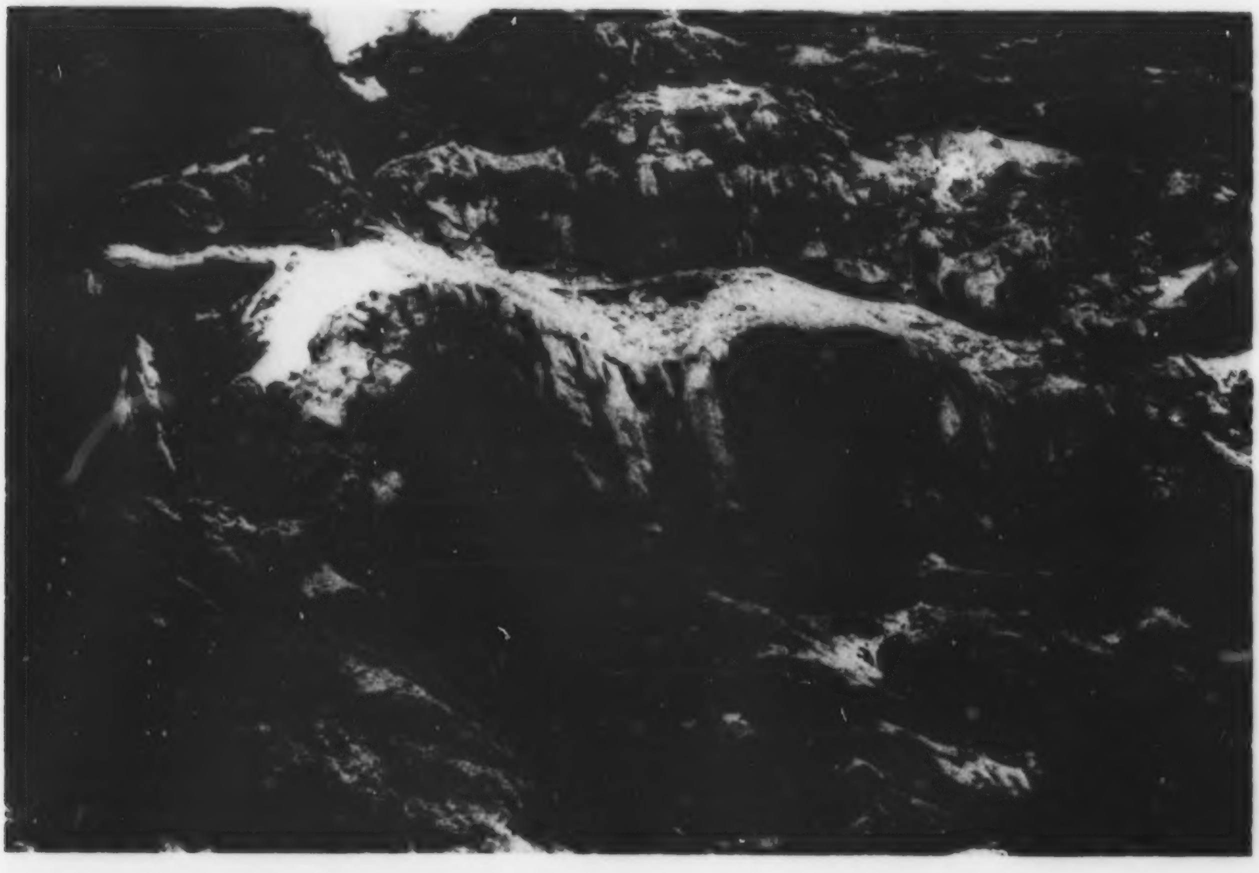


Figure 27. Lenticular shapes in the Nansen Formation (centre of picture) interpreted as mounds of phylloid algae. These mounds are about 10 m thick. Vicinity of Section E1, de Vries Glacier. ISPG photo. 2525-6.

The evaporites, reefs and sandstones of the Middle member are here interpreted as tongues of the Otto Fiord and Hare Fiord formations. Interpretations of these formations are given in the relevant sections of this report, and it suffices to state that the evaporites and reefs were part of a subaqueous sequence in the central part of a restricted basin. A lobe of basinal sediments, perhaps deposited in an embayment, succeeded the normal marine carbonates of the Lower member of the Nansen Formation. Submarine outer fan deposits in the form of sandstone and shale were deposited after the reefs and evaporites.

Like the underlying submarine fan deposits, the lowest part of the Upper member has deep water characteristics, such as the presence of sponge spicules and transported silty limestone, but shallow water indicators appear to be present in the remainder of the unit. The pervasive dolomitization hinders interpretation of the succession; nevertheless, some tentative conclusions can be drawn. A large part of the dolomite is laminated, contains algal units, and is unfossiliferous, indicating a somewhat restricted peritidal or very shallow subtidal origin.

Age and correlation. The age ranges of the Nansen Formation fall into two groups: a Bashkirian-Leonardian range and a Moscovian-Leonardian range.

Where the formation is fully developed, such as in the dolomite lithofacies in the Yelverton Inlet/de Vries Glacier area, the oldest age determinations, from the lower part of the Lower member, are Bashkirian (GSC locs. C-45383 and C-45421, Appendix 3). The Middle member yielded foraminifers of Moscovian age from the base of one of the bioherms (GSC loc. C-45449, Appendix 3). The exact age range of the Upper member is somewhat uncertain. It ranges from presumably Moscovian, as indicated by the age of the underlying Middle member, to at least Leonardian. The Leonardian or even younger age is based on a number of brachiopod

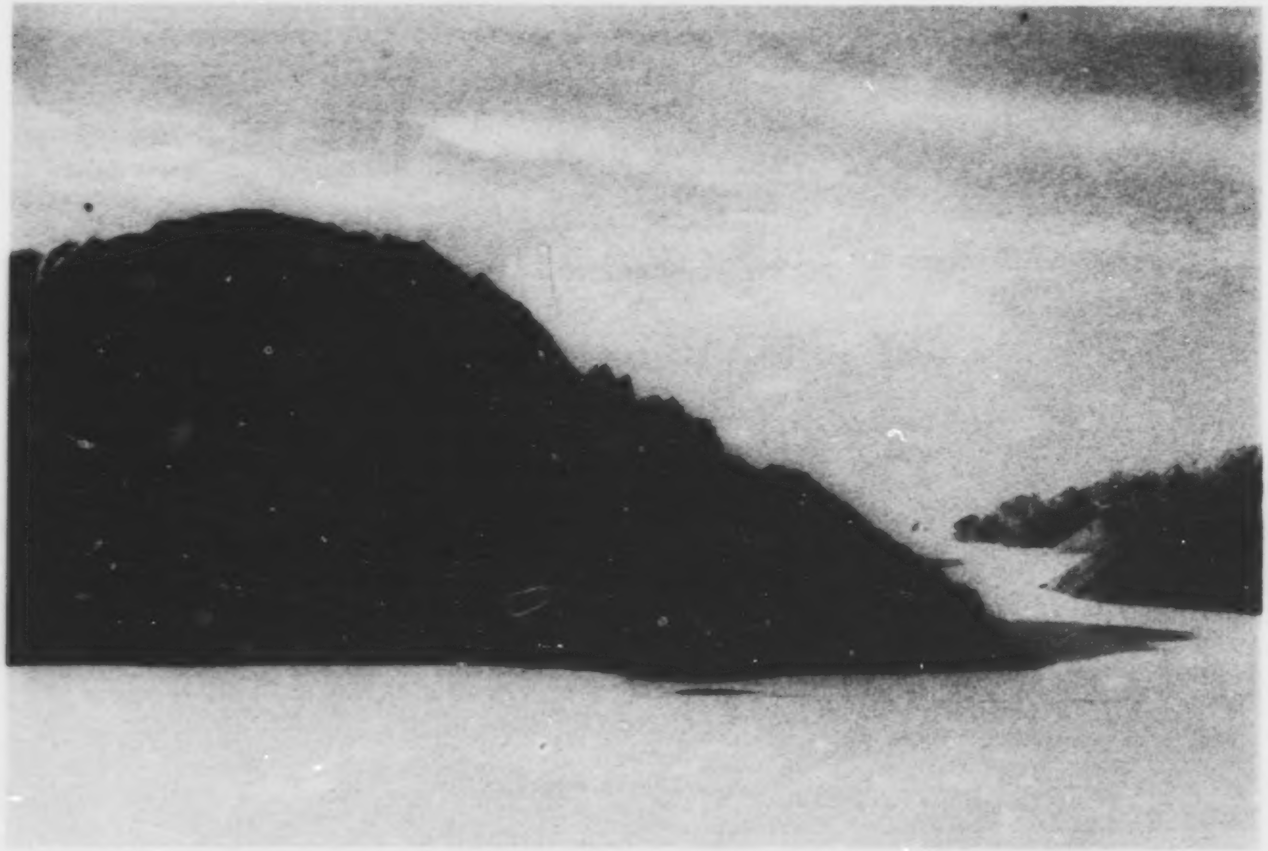


Figure 28. Light coloured dolomite of the Nansen Formation directly overlying dark, lower Paleozoic basement rock, and overthrust from the left (south) by more basement rocks. View westward from Section G across M'Clintock Glacier; Section G was measured on strike with the exposures shown. ISPG photo. 2525-7.

collections from the uppermost few metres of the formation on the west side of Yelverton Inlet (among them GSC loc. C-45391; Appendix 3).

A brachiopod fauna from the base of Section G (GSC loc. C-83322) is also worthy of note. It contains *Gigantoproductus*, which outside the Sverdrup Basin is no younger than early Namurian. However, there are also indications that Sverdrup Basin formed a protected enclave and that a number of species survived here much longer than elsewhere (Bamber, pers. comm., 1988); thus, these brachiopods may be younger than early Namurian.

At Yelverton Pass and along the valley toward Tanquary Fiord, the age range of the formation is considerably narrower. It is no older than Moscovian (GSC locs. C-45471 at location 75-MSA-83, and C-45191 in Section P) and the youngest part is late Gzhelian in age (GSC locs. C-45478 at Field Station 15, and C-45226 in Section P). The uppermost Carboniferous and Lower Permian rocks are missing on the Tanquary Structural High and were presumably removed by erosion prior to deposition of the oldest Triassic units in the area.

The sections belonging to the northwest arm of the carbonate belt yielded Moscovian ages only (Section M, GSC locs. C-70060 and C-70066; Section G, GSC locs. C-83334, C-83339, and C-83345). These fossils come from the lower part of the formation; no age for the upper part is available.

The Lower and Middle members of the Nansen Formation at Yelverton Inlet, and the lower part of the formation at Yelverton Pass and in the northwestern belt correlate with the Canyon Fiord Formation, which is generally of Moscovian age. Furthermore, if the dating of the brachiopod fauna from the base of Section G (GSC loc. C-83322) can be accepted, a large part of the Borup Fiord Formation should correlate with the lowest Nansen Formation in the northwestern carbonate belt. The evaporites of the Middle member are an extension of the evaporites of the Otto Fiord Formation in the basinal area, as are the reefs and overlying sandstone-shale sequence, which ties with the lower part of the Hare Fiord Formation. The Leonardian parts of the formation should be correlative with the unnamed formation of Nassichuk and Wilde (1977).

Formations of the basinal belt

Borup Fiord Formation

Definition, distribution, thickness, and contact relationships. The definition of the Borup Fiord Formation (Thorsteinsson, 1974) has been discussed in the foregoing section on the carbonate belt. The Borup Fiord Formation on northern Ellesmere Island occurs as two different lithofacies: a typical conglomerate-sandstone lithofacies, which is present in the carbonate belt, and a shale-siltstone lithofacies, which is found in the basinal belt. Shale and siltstone now assigned to the Borup Fiord Formation were probably part of Blackadar's (1954) "Guide Hill group". He mentioned black and purple shale and grey limestone in his description, but it is not clear whether he referred to interbeds in the conglomerate-sandstone sequences or whether he considered these rocks a separate lithofacies. In any case, the shale and siltstone around Parker Bay are now assigned to the Borup Fiord Formation, and the sandstone and conglomerate at Guide Hill and Feilden Peninsula belong to the Canyon Fiord Formation.

The most extensive outcrop areas of the shale-siltstone lithofacies of the Borup Fiord Formation are at the head of M'Clintock Glacier. The sections are incomplete and faulted, but it is estimated that the thickness of the Borup Fiord Formation there exceeds 900 m. Another good outcrop area is at Hamilton Bluff near Parker Bay, where 500 m of the lower part of the formation are present. Between these two major outcrop areas the formation is present in a number of incomplete sections in areas of limited outcrop.

Around the head of Clements Markham Inlet, at M'Clintock Glacier and near Parker Bay, the lower contact of the Borup Fiord Formation with the Emma Fiord Formation is a slight angular unconformity. On the north side of the unnamed river between Crescent Glacier and Clements Markham Inlet, the formation is underlain with angular unconformity by lower Paleozoic rocks. The upper boundary with the Otto Fiord Formation is gradational.

Lithology. Several incomplete sections of this facies were examined near the upper part of M'Clintock Glacier. In Section F3, a major twofold subdivision can be recognized. The lower part of the formation consists predominantly of maroon, slaty shale, and the upper part is mostly light green shale (Fig. 29). Both subdivisions contain interbeds of siltstone and minor sandstone. At the base of the exposed succession, small, lenticular units of anhydrite are present (Fig. 30).

The shale is massive and uniform in appearance, but very thin bedded or laminated intervals are also present. Ripple marks were observed at several places. The shale is commonly calcareous and silty, both properties varying throughout the section. Siltstone is the next most common rock type, and is present in both red and green varieties. In several areas it overlies the shale with gradational contact, forming the upper part of coarsening-upward sequences up to several tens of metres thick. Most of the siltstone is thin or very thin bedded. Ripple marks are common, whereas bioturbation, crossbeds and desiccation cracks are present, but rare. The sandstone is thin bedded, very fine grained, calcareous and light coloured. Ripple marks and trough and planar crossbedding are common. Desiccation cracks were also observed. XRD analysis (Appendix 4) shows a variable composition, generally low in mica and high in chlorite and carbonate.

The shale-siltstone lithofacies is almost barren of fossils. Only one zone of small, spherical stromatolites was seen.

At Hamilton Bluff (Field Stations 30 and 31) about 500 m of limestone, siltstone and shale are present. The base of the sequence consists of about 10 m of conglomerate and quartzite. This is overlain by about 300 m of yellow weathering, thin and very thin bedded, argillaceous limestone. Some of the limestone is nodular, but most shows laminae which are, at least in part, of stromatolitic origin. Bioturbation was also observed. The limestone unit is overlain by about 200 m of red weathering siltstone. The siltstone is calcareous and interbedded in the upper part with fine grained, impure sandstone.

Exposures are also present on the mountain tops about 9 km southeast of the head of M'Clintock Inlet (Field Station 42) where nodular limestone is interbedded with maroon shale and siltstone. Maroon and green, slaty shale is present at Clements Markham Inlet (Section L2). In the upper part of the section it is interbedded with dark carbonate and mature, light coloured sandstone.

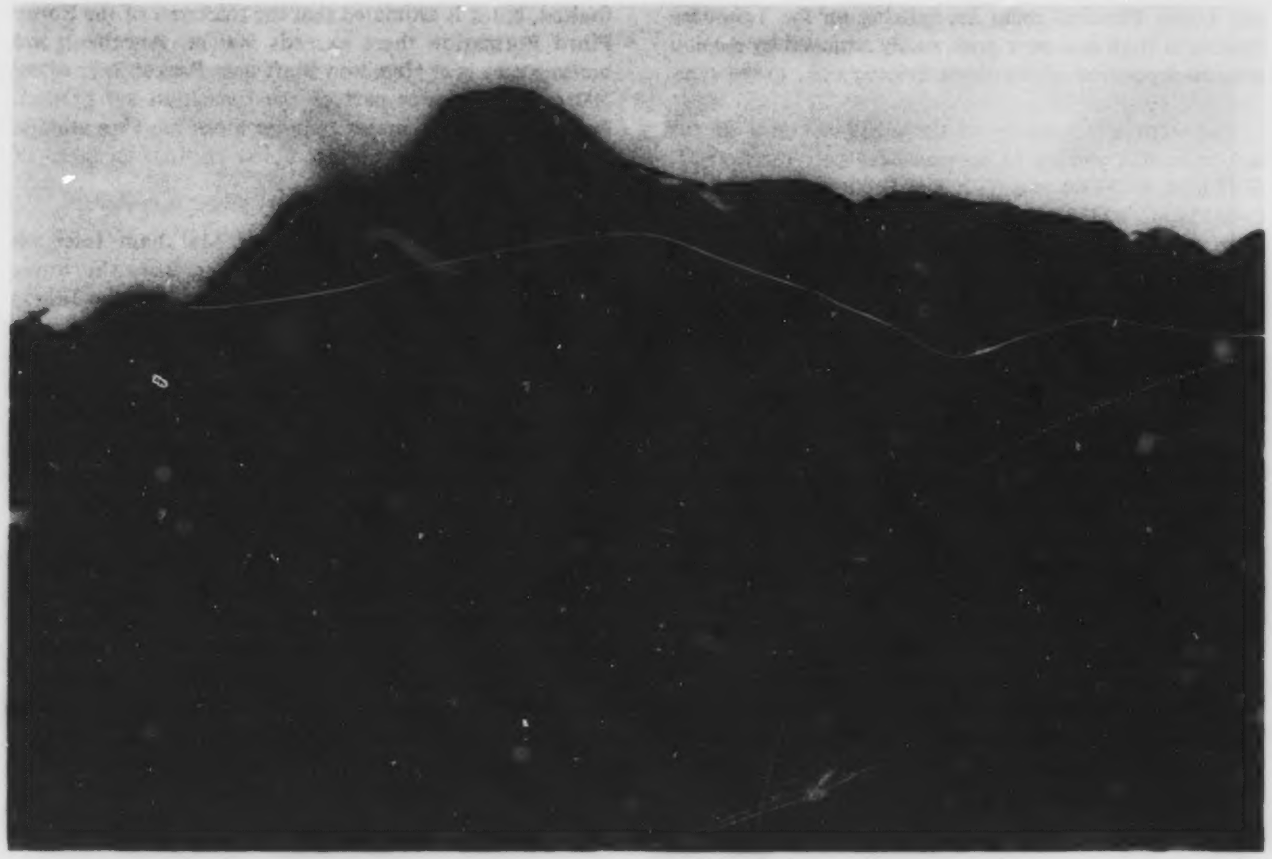


Figure 29. Basinal facies of the Borup Fiord Formation, consisting of recessive, slaty shale with ledges of resistant siltstone and fine grained sandstone. Skyline is formed by the lower evaporites of the overlying Otto Fiord Formation. Upper part of Section F3, upper M'Clintock Glacier (see Figure 30). ISPG photo. 972-36.

Mode of origin. The fine grained nature of the rocks and the lack of marine fossils at the head of M'Clintock Glacier are characteristics of floodplain deposits (Reineck and Singh, 1973). The lack of fining-upward cycles implies flood basin and coastal plain deposition, in the lowest part of the floodplain where the fine material settles out. Thus, there is a preponderance of massive or laminated mudstone and shale. The siltstone beds with crossbedding may represent crevasse splays. Sandy beach deposits appear to be absent from the sequence and the flood basin/coastal plain deposits at upper M'Clintock Glacier probably merged imperceptibly into the supra- or intertidal deposits of Hamilton Bluff.

The Hamilton Bluff sequence is very poorly exposed. Its interpretation as a peritidal sequence is based on the presence of limestone, some of which is nodular and displays structures reminiscent of flaser bedding, a characteristic feature of tidal flats (Reineck and Singh, 1973). Some of the laminae in the limestone may be of algal origin, indicating supratidal deposition. Within the M'Clintock Glacier sequence is one interval with spherical stromatolites, another indicator of the very gradual change from nonmarine to marine deposition between M'Clintock Glacier and Hamilton Bluff.

Age and correlation. No fossils of biostratigraphic value were found in the Borup Fiord Formation in the basinal belt nor, for that matter, anywhere else in the formation in the project area. The lower age of the formation in the basinal belt is constrained by the late Viséan–early Namurian conodont fauna in the underlying Emma Fiord Formation near Hamilton Bluff (GSC loc. C-99616, Appendix 3). The upper age is limited by the Moscovian age of the basal Hare Fiord Formation at the head of M'Clintock Glacier (GSC loc. C-83369). No fossils were recovered from the Otto Fiord Formation, which overlies the Borup Fiord Formation directly. The possible age of the Borup Fiord Formation in the basinal belt therefore ranges from Serpukhovian to Moscovian; compared to that in the carbonate belt, which is Serpukhovian–Bashkirian. Presumably, with the large, unfossiliferous interval between the top of the Borup Fiord Formation and the Moscovian datum point from the Hare Fiord Formation, the age range of the formation in the basinal belt is also Serpukhovian–Bashkirian. The conglomerate-sandstone and shale–siltstone lithofacies are here interpreted, mainly on the basis of similarity in stratigraphic position, as representing, respectively, proximal and distal deposits of one and the same formation. Although no transitional deposits between these lithofacies have as yet been found, this is not unexpected in view of the discontinuous nature of Borup Fiord Formation outcrops.

Otto Fiord Formation

Definition. The Otto Fiord Formation (Thorsteinsson, 1974) is an evaporite sequence of mainly Bashkirian age that is present in the central part of Sverdrup Basin. It is exposed in a stratigraphic sequence in the Hare Fiord area of northern Ellesmere Island and in numerous diapirs on Axel Heiberg and other islands. Where exposed, the thickness of the formation varies from about 200 to 300 m. It consists of anhydrite with minor interbeds of dark grey limestone. The Otto Fiord Formation is underlain with gradational contact by the Borup Fiord Formation and is a facies equivalent of the lower part of the Nansen Formation. The evaporites are generally overlain with sharp contact by siltstone, shale and limestone of the Hare Fiord Formation. Locally, the contact is drawn below Waulsortian-type reef mounds that may form the lowest part of the Hare Fiord Formation.

Nassichuk and Davies (1980) presented a detailed study of the stratigraphy and sedimentology of the Otto Fiord Formation, and concluded that it was deposited in a subaqueous, hypersaline, marine environment. They pointed out that two, basic, sedimentary rhythms can be recognized: limestone-anhydrite rhythms, up to 50 m thick for a single rhythm; and limestone-anhydrite-sandstone rhythms, up to 64 m thick. Sandstone units may be more than 20 m thick and are interbedded with shale. The presence of sandstone and shale in the Otto Fiord Formation in the Hare Fiord area is of some importance, because the Hare Fiord Formation on northern Ellesmere Island also contains considerable amounts of sandstone and shale.

Blackadar's (1954) reconnaissance extended far enough into Clements Markham Inlet to encounter the Otto Fiord Formation. Black shale on the southeast side of the inlet, included by him in the "Sail Harbour group", is now assigned to the Otto Fiord Formation. Christie (1964) briefly described the Carboniferous-Permian succession at the head of Clements Markham Inlet and included all rocks in a single map unit. The gypsum occurrences mapped south of the head of the inlet are now included in the Otto Fiord Formation. The gypsum along Gypsum River on the northwest side of Clements Markham Inlet, and most of the carbonate breccia described by Christie, belong to the Mount Bayley Formation.

Distribution, thickness, and contact relationships. The Otto Fiord Formation is present in the nunataks in the upper part of M'Clintock Glacier. No complete sections were measured there because the sequence is folded and faulted, but the thickness of the formation exceeds

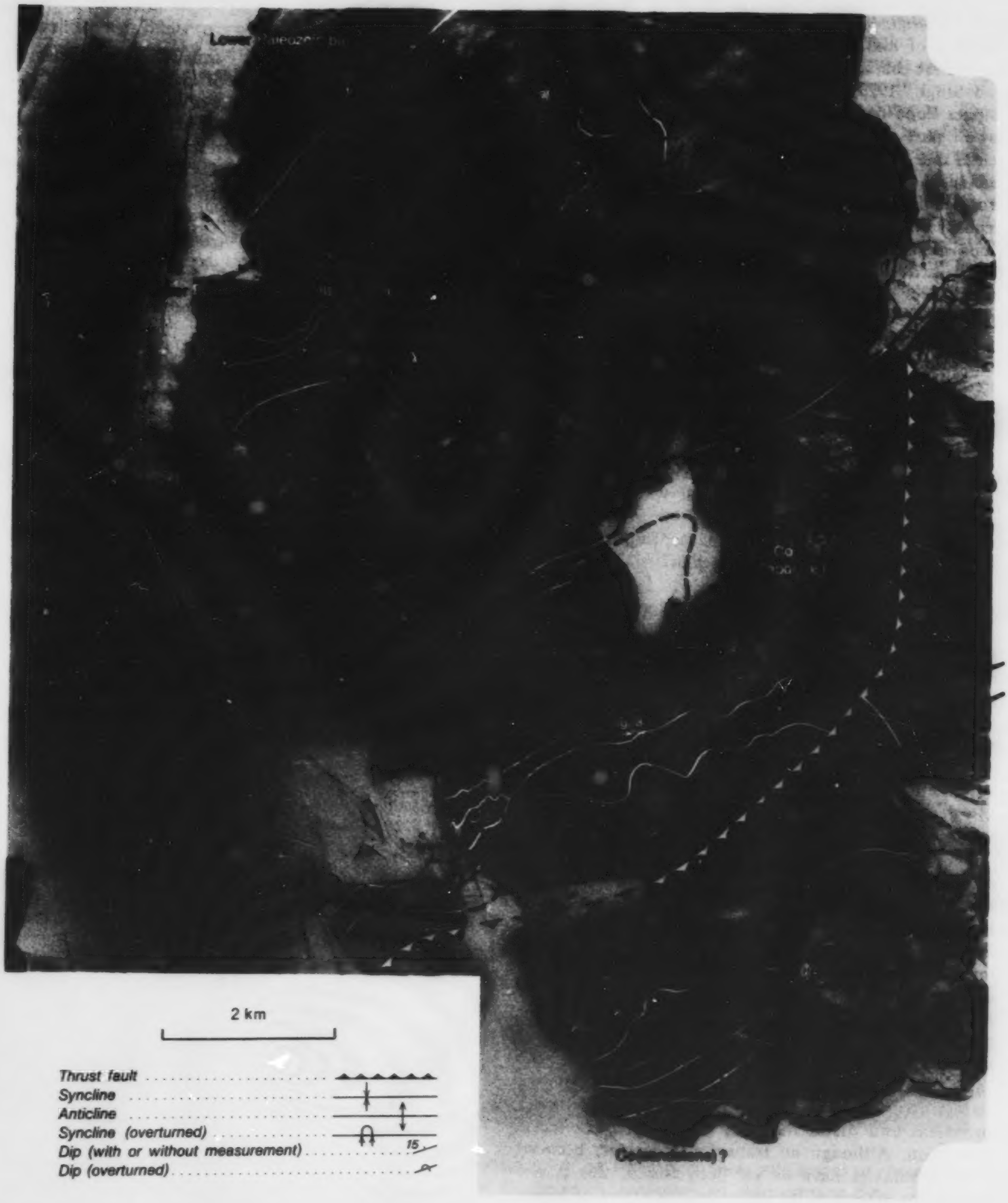

Lower Paleozoic
2 km
Thrust fault
Syncline
Anticline
Syncline (overturned)
Dip (with or without measurement)
15
Dip (overturned)
Co(sandstone)?

Figure 30. *Vertical airphoto showing the southwestern part of the large nunatak in the upper reaches of M'Clintock Glacier. Lower Paleozoic basement in the northwestern corner is overlain by a complete sequence of southeast dipping Carboniferous formations (ranging from Emma Fiord to Hare Fiord) and Tertiary Eureka Sound Formation. The airphoto shows a lens of anhydrite within the Borup Fiord Formation. The Otto Fiord Formation comprises two lithofacies. The main lithofacies consists of anhydrite. Enclosed in the anhydrite is part of a large lens of the second lithofacies, which comprises sandstone and shale. The Hare Fiord Formation contains the reef shown in Figure 31. Locations of Sections F1, F2, and F3, and Field Station 22 are plotted. For location of airphoto (NAPL A-16982-13) see Figure 5.*

KTe–Eureka Sound breccia; Chf–Hare Fiord typical sandstone–limestone lithofacies (not marked) and reef lithofacies; Co–Otto Fiord Formation evaporite lithofacies and sandstone–shale lithofacies; Ce–Emma Fiord Formation conglomerate, shale, and sandstone; Cbf–Borup Fiord Formation. Geological symbols as in Figure 2.

1000 m. Another large exposure occurs southwest of the head of Clements Markham Inlet (Fig. 6). There the formation is intensely folded and thrusted; its thickness may be similar to that of the outcrop at M'Clintock Glacier.

The Otto Fiord Formation is underlain by the shale and siltstone of the Borup Fiord Formation. The contact is gradational. Where the formation is directly overlain by the sandstone and shale of the Hare Fiord Formation, the contact is a sharp paraconformity. Where the basal part of the Hare Fiord Formation consists of reefs, the contact is gradational, with the evaporites interbedded and interfingering with the lower part of the reefs. The upper contact is exposed only in the M'Clintock Glacier area. At Clements Markham Inlet, the Otto Fiord Formation is the highest preserved formation of the basinal belt.

Lithology. The Otto Fiord Formation consists of anhydrite and of sandstone and shale. The two lithofacies occur as major alternating units several hundreds of metres thick. The amount of shale and sandstone increases from M'Clintock Glacier toward Clements Markham Inlet. At M'Clintock Glacier, anhydrite constitutes more than half of the formation (Fig. 30), whereas at Clements Markham Inlet, shale and sandstone are the dominant lithofacies of the Otto Fiord Formation (Fig. 6). The lesser lithofacies occurs as lenses, several kilometres wide, within the dominant lithofacies.

The thickest occurrence of the anhydrite lithofacies is found in the southernmost part of the M'Clintock nunatak, where evaporites from the lower part of the formation are present. The outcrops are structurally complex, and no sections were measured or described. Thinner intervals of evaporite are present in the upper part of the formation (Section F2) in the same area (Fig. 31). There the anhydrite shows a variety of structures, ranging from thick bedded with interval lamination, through distorted lamination, and incipient "noduling" to complete "chicken wire" nodules. Some of the anhydrite is granular, with intergranular gypsum and reworked dolomite and shale clasts.

The evaporites are interbedded with two types of dolomite. One type comprises thin to medium thick beds of skeletal debris from reef mounds in the upper part of the formation; the other type is a fine crystalline, thin bedded, xenotopic, very dark grey, very slightly silty dolomite.

Several sections were measured in the sandstone–shale lithofacies of the Otto Fiord Formation. At the M'Clintock Glacier nunatak, the thickness of the lithofacies was estimated to be about 1000 m. About 500 m of the upper part of the lithofacies, comprising sandstone interbedded with siltstone and shale, were measured at this locality (Section F2, Fig. 32). The sandstone forms about 40 per cent of the succession. It is dark to medium grey, variably sorted, mostly fine grained and thin bedded. Many beds are rather featureless, but in others bioturbation, lamination, and low-angle cross-bedding occur. Several beds show channelling, basal conglomerates and thin fining-upward sequences. Incomplete Bouma sequences are present. The siltstone is dark grey, usually slightly calcareous and thin bedded. In the uppermost part, the sandstone gives way to shale, siltstone and black dolomite. The contact with the overlying anhydrite is gradational, and the two lithofacies interfinger laterally (Fig. 31). In composition, the sandstones vary from quartzarenite to sublitharenite. The cement and matrix consist mostly of dolomite, calcite and some chlorite (see Appendix 4).

At Clements Markham Inlet, the lithofacies was examined in Section L1. Overall, the shale/sandstone ratio in the Clements Markham area is much higher than in the M'Clintock Glacier area (Fig. 33). The lower part of the section was not examined in detail. The middle part (Units 1–5) comprises slaty, light green and purple siltstone and shale interbedded with light coloured sandstone. The sandstone is impure and varies from fine to medium grained. It is thick bedded or massive and shows rare ripple marks. Conglomerate and maroon sandstone were seen in talus. Units 1 to 5 show similarities to the basinal facies of the Borup Fiord Formation and have only tentatively been included in the Otto Fiord Formation. In the project area, massive, light coloured sandstone intervals are uncommon in the Borup Fiord Formation and are restricted to the submarine fan associations of the Otto Fiord and Hare Fiord formations.

The upper part of the section (Units 6–8) consists of shale interbedded with sandstone. A large lens of anhydrite is present along strike. The amount of sandstone interbedded with the shale decreases substantially upward from about one third to only an occasional bed in the shale succession. The shale is medium to dark grey, very soft, and papery weathering. It consists mostly of mica, chlorite and carbonate (see Appendix 4 for composition). The interbedded sandstone is thin bedded or laminated. Vague fining-upward cycles can be seen and slabs with flute marks were found in the scree. Grain size ranges from coarse sand to silt size. In composition, quartz makes up about 40 to 50 per cent of the grains, chert 40 per cent or less, and carbonate grains, rock fragments, feldspar and mica the remainder (see Appendix 4, GSC loc. C-83434). In some beds, the proportion of carbonate grains exceeds 50 per cent.

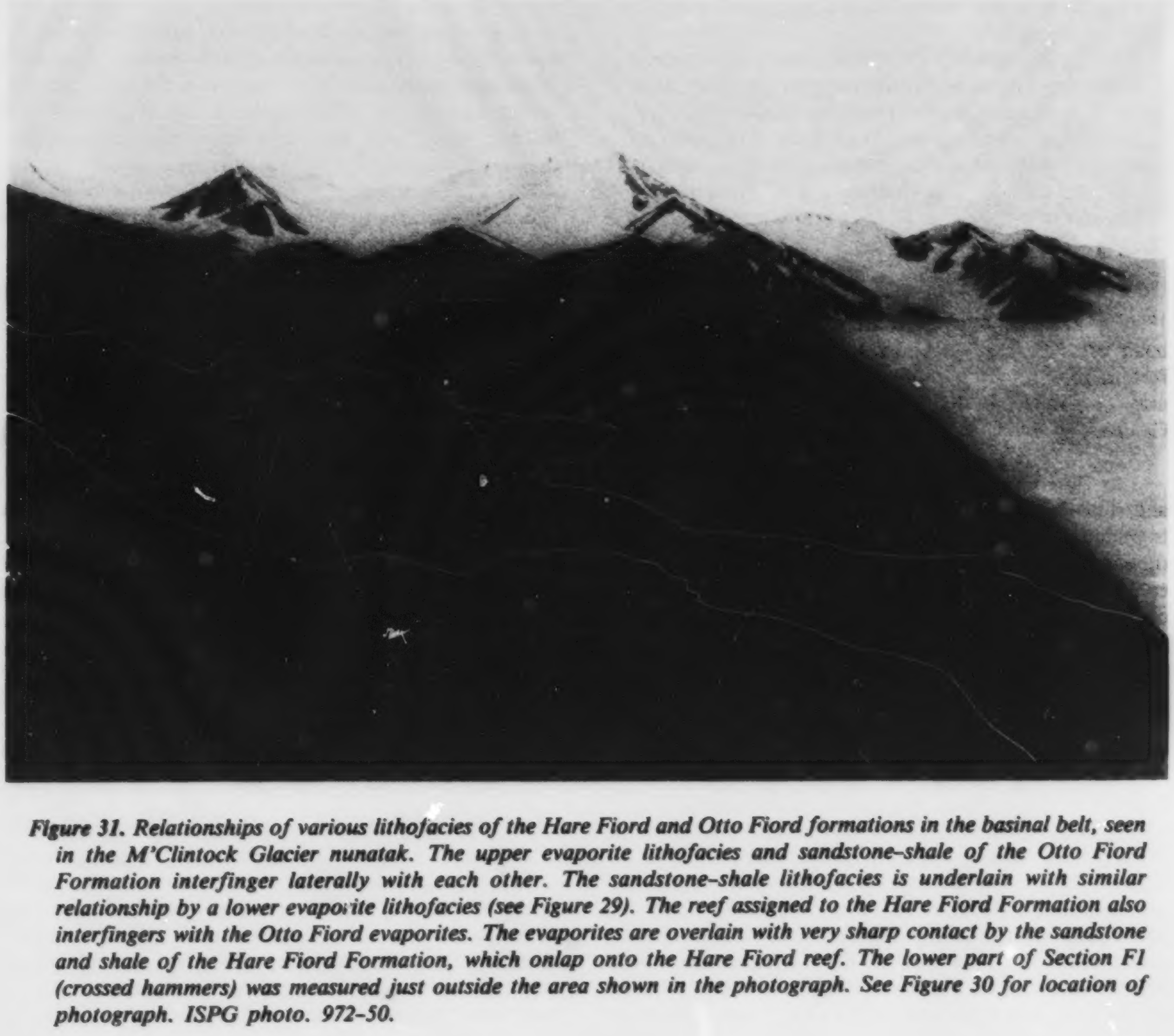


Figure 31. Relationships of various lithofacies of the Hare Fiord and Otto Fiord formations in the basinal belt, seen in the M'Clintock Glacier nunatak. The upper evaporite lithofacies and sandstone–shale of the Otto Fiord Formation interfinger laterally with each other. The sandstone–shale lithofacies is underlain with similar relationship by a lower evaporite lithofacies (see Figure 29). The reef assigned to the Hare Fiord Formation also interfingers with the Otto Fiord evaporites. The evaporites are overlain with very sharp contact by the sandstone and shale of the Hare Fiord Formation, which onlap onto the Hare Fiord reef. The lower part of Section F1 (crossed hammers) was measured just outside the area shown in the photograph. See Figure 30 for location of photograph. ISPG photo. 972–50.

Mode of origin. Based on a number of lines of evidence, Nassichuk and Davies (1980) interpreted the evaporites of the Otto Fiord Formation around Hare Fiord as subaqueous, basinal evaporites. Part of that evidence was the axial position of the anhydrite, the presence of interbedded carbonate rocks and marine fossils, as well as the types of preserved sedimentary structures; for example, lamination, and the absence of stromatolites. Similar arguments are valid for the anhydrites of northern Ellesmere Island; a basinal origin is also supported by interpretation of the shale–sandstone lithofacies as submarine fan deposits.

Mutti and Ricci (1975) classified submarine fan deposits and described a number of facies associations characteristic of different turbidite environments. These environments are the basin plain environment, the non-channelized outer fan environment and the channelized or inner deep-sea fan environment. Characteristic for the basin plain association is shale with interbeds of laminated sandstone. Sole markings and ripple marks may be present in the sandstone beds. The shale–sandstone facies of the Otto Fiord Formation of Clements Markham Inlet displays similar characteristics, and a basin plain environment in a somewhat restricted basin is the most likely origin for the shale-dominated, upper part of the sequence. The lower part of the sequence, which contains more and thicker sandstone beds, may represent a shift of a fan, which brought outer fan deposits closer to that particular area.

The outer fan association is characterized by thick sandstone lenses or lobes that were deposited at or near the mouths of fan channels, and by shale, thin bedded sandstone, and siltstone from the interlobe areas. The sandstone interbeds of the interlobe areas are similar to the sandstones interbedded with the basin plain shales, but the sandstone/shale ratio is higher and some cyclicity should be present. These features are present in the shale/sandstone lithofacies at M'Clintock Glacier and the

Figure 32. The sandstone–shale lithofacies of the Otto Fiord Formation, largely comprising thin bedded, fine and medium grained, crossbedded sandstone. Unit 42, Section F2, upper M'Clintock Glacier. ISPG photo. 972–41.

sequence there is interpreted as comprising interlobe deposits of a submarine fan.

In summary, the Otto Fiord basin of northern Ellesmere Island can be visualized as a local, restricted basin with abundant terrigenous influx from the margins. Terrigenous sediments are also present in the larger, central Otto Fiord basin to the southwest, but these clastic rocks have been interpreted as deltaic sediments (Nassichuk and Davies, 1980), and are thus from a more marginal position in the basin than the submarine fan deposits of northern Ellesmere Island.

Age and correlation. In the project area, no fossils of biostratigraphic value were found in the Otto Fiord Formation. The lower part of the overlying Hare Fiord Formation is of Moscovian age; thus, the Otto Fiord Formation is not younger than Moscovian. No direct constraint for the lower age limit is available; the underlying siltstone-shale lithofacies of the Borup Fiord Formation is devoid of diagnostic fossils. In the conglomerate-sandstone lithofacies, the upper age of the Borup Fiord Formation is Bashkirian; thus, a Bashkirian-Moscovian age is implied for the Otto Fiord Formation in northern Ellesmere Island. Nassichuk and Davies (1980) reported a similar age for the Otto Fiord Formation farther southwest near Hare Fiord. The Otto Fiord Formation correlates with the lower part of the Nansen Formation, and additional physical evidence is found in the evaporite tongue in the Nansen Formation of de Vries Glacier. The gradational contact with the underlying Borup Fiord Formation may indicate a diachronous boundary, with the contact presumably becoming older in the central part of the basin.

In some aspects, the sandstone-shale lithofacies of the Otto Fiord Formation is identical to the sandstone and shale in the lower part of the Hare Fiord Formation. The associated intervals of evaporites were used to distinguish the two formations.

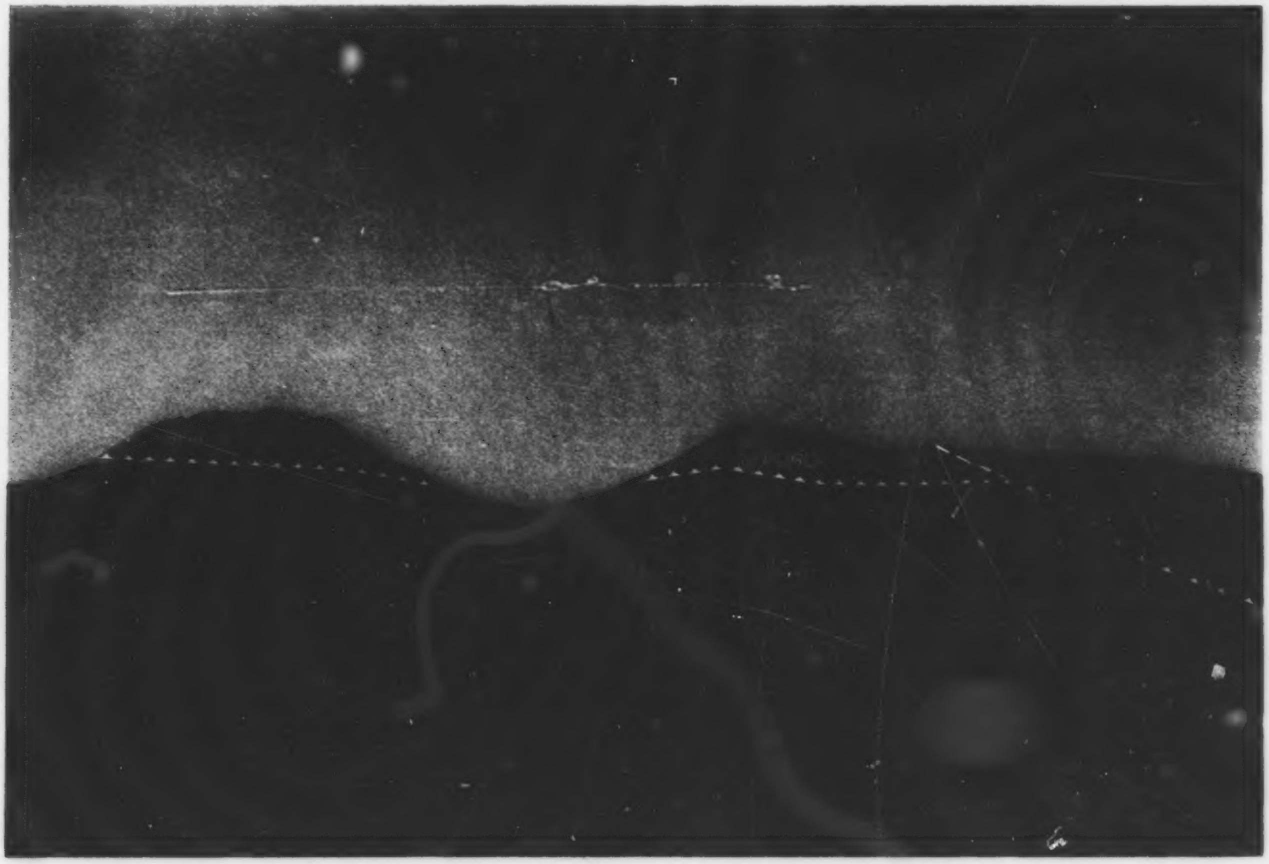


Figure 33. Recessive weathering soft shales of the Otto Fiord Formation forming gentle slopes along the west side of upper Clements Markham River. They are overthrust by the more resistant weathering, slaty shale of the Borup Fiord Formation. See Figure 6 for location and view direction of photograph. ISPG photo. 2525-9.

Hare Fiord Formation

Definition. The name Hare Fiord Formation was proposed by Thorsteinsson (1974) for the Upper Carboniferous and Lower Permian deep water succession of Sverdrup Basin, to the southwest of the project area. There the lithology of the Hare Fiord Formation is varied, but consists generally of thin bedded, dark coloured siltstone, shale, limestone, and, locally, sandstone and bioherms. Maximum thickness of the formation is about 1250 m. The bioherms are present in the lower and middle parts of the formation, whereas the sandstone is restricted to the lower part of the formation. Davies (1977) presented a detailed interpretation of the Hare Fiord Formation around Hare Fiord and Nansen Sound, in which he showed that it consists of a variety of facies, including bioclastic and lithoclastic turbidites and debris flows. The Hare Fiord Formation is overlain disconformably by the van Hauen Formation, which is of late Artinskian and Kungarian age (Nassichuk and Wilde, 1977).

Distribution, thickness, and contact relationships. The formation is present only at the head of M'Clintock Glacier, where about 150 to 250 m of the formation are preserved below the Eureka Sound Formation of Tertiary age. The characteristics of the lower boundary of the formation vary. Where the base of the formation consists of interbedded sandstone and shale, these rocks overlie the evaporites of the Otto Fiord Formation with a sharp, paraconformable contact; where the basal part of the formation consists of bioherms, these bioherms interfinger with the evaporites of the Otto Fiord Formation and are in turn overlain paraconformably by the sandstone and shale of the Hare Fiord Formation. The position of the boundary is based on the original definition of the Hare Fiord Formation, which includes reefs at the base, but that boundary definition is not very satisfactory in northern Ellesmere Island, where the reefs are associated with the evaporites rather than the overlying turbidites. This, however, is a problem of nomenclature that has to be resolved on a basin-wide scope.

Another occurrence of Hare Fiord type units is at de Vries Glacier, where reefs, sandstone, and shale form part of the middle member of the Nansen Formation (Fig. 16). These rocks are interpreted as a tongue of the Hare Fiord Formation, intercalated in the Nansen Formation.

Lithology. At M'Clintock Glacier, the Hare Fiord Formation consists of a single reef, estimated to be 200 m thick, which is overlain by an incomplete section of about 150 m of sandstone, shale, and carbonate (Fig. 31). Owing to the precipitous outcrop and danger of rockfall, no detailed examination of the reef was made, but the upper part of the flanks of the mound were studied. The carbonates there consist of dolomite and recrystallized limestone. Original clasts are barely recognizable. The dolomite is medium crystalline. It contains fragments of crinoids, bryozoans and brachiopods, and ghosts of pelletoids. The limestones are calcirudites and, where recognizable, contain brachiopod, crinoidal and other fragments.

The lower part of the bedded sequence consists of sandstone, silty shale and minor siltstone (Fig. 34). The sandstone is light coloured and generally thick bedded. Sedimentary structures are rare. Crossbedding is virtually absent, and only a few poorly defined basal channels, some ripple marks and parallel lamination were observed. The sandstone is fine or medium grained sublitharenite and subarkose. Mica, various feldspars and rare dolomite grains are present. In some instances, the texture is quartzitic, but more commonly dolomite or chlorite cements are present. The sandstone contains feldspar, the maximum percentage of which is 15 per cent (see Appendix 4, GSC loc. C-83360). The shale is very dark grey, micaceous and variably silty. It is papery weathering. The amount of shale interbedded with the sandstone increases upward in the sections. In the lower part, sandstone and shale are arranged in distinct cycles, about 6 m thick, with the shale comprising more than half of the thickness. The uppermost 18 m of the section contain rocks that are more typical of the formation. They comprise thin to medium bedded limestone and minor calcareous and argillaceous dolomite. The limestone is dark coloured and consists of lime mudstone and skeletal wackestone. The contact with the sandstone and shale is gradational.

Mode of origin. The reef probably belongs to the "Waulsortian" type described by Davies et al. (1987). These reefs are characterized by accumulations of bryozoans, crinoids, and other skeletal material, and pervasive cementation. They developed on the lower part of high-relief carbonate shelf edges, which in this particular case is the Nansen Formation of the surrounding carbonate shelf. The overlying interbedded sandstone and shale are very similar to the ones in the underlying Otto Fiord Formation, and like those are probably interlobe deposits of a deep sea fan. This interpretation is compatible with Davies' (1977) interpretation of the Hare Fiord Formation as a deep water, slope and basin succession.

Age and correlation. The age of the lower part of the Hare Fiord Formation in the project area is well established. Moscovian fossils were found at M'Clinlock Glacier (GSC loc. C-83369, Section F1) and at the base of the reefs in the middle part of the Nansen Formation at de Vries Glacier (GSC loc. C-45449). The reported upper

Figure 34. Thin bedded sandstone, siltstone and shale of the Hare Fiord Formation overlying massive anhydrite and gypsum of the Otto Fiord Formation along a very sharp contact. Upper part of Section F1, in M'Clintock Glacier nunatak (see Figure 30 for location). ISPG photo. 2525-10.

age is early Artinskian (Thorsteinsson, 1974). The Hare Fiord Formation correlates with the upper part of the Nansen Formation and is the basinal equivalent of the shelf carbonates.

Cape Nares carbonate belt

Stratigraphy. The occurrences of Carboniferous and Permian rocks, near Cape Nares and on Ward Hunt Island, that form the Cape Nares carbonate belt were not examined in detail during the present study. They were first reported by Christie (1957, 1964) and were also examined by Nassichuk (1967). Christie (1964) gave a brief description of the succession. The lowest part consists of conglomerate overlain by red arkose and conglomeratic arkose. These two terrigenous units are overlain by thick bedded limestone. Thompson (1961) described Upper Carboniferous fusulinids and Christie (1964) listed Carboniferous or Lower Permian brachiopods from the exposures.

Recently, Davies and Nassichuk (in press) assigned the limestone to the Nansen Formation and the underlying conglomerate and red arkose to the Borup Fiord Formation. They list a Bashkirian (earliest Late Carboniferous) age for the lower part of the Nansen Formation. The Borup Fiord Formation is 270 m thick, and 200 m of the Nansen Formation are preserved. At Cape Nares, the Borup Fiord Formation overlies mid-Proterozoic gneiss of the Cape Columbia belt, while, on Ward Hunt Island, the basement consists of metamorphosed sedimentary and volcanic rocks of Late Proterozoic to Ordovician age (Trettin, 1987).

Discussion. It has been pointed out above (see section on the origin of the Canyon Fiord Formation) that the Bashkirian and younger carbonates of the Cape Nares carbonate belt occupy an area where the northern source area of the mid-Upper Carboniferous Canyon Fiord Formation, exposed at the heads of M'Clintock Inlet and Markham Fiord, should have been. This constitutes a paleogeographic discrepancy that has two possible solutions:

1. The Canyon Fiord Formation in the northwestern marginal belt was derived from a local, narrow source that lay south of the Cape Nares carbonate belt, and which was formed by a basement culmination. Alternatively, if the limited directional data from the Canyon Fiord Formation are ignored, the formation could have been deposited from a northeastern direction on a delta that formed a salient onto the carbonate shelf.

2. The present location of the Cape Nares carbonate belt is the result of Eurekan strike-slip faulting. In this case, dextral strike-slip, along the northern continental margin, associated with seafloor spreading in the Nansen Ridge (see Figure 40), would be the most probable mechanism. Restraints imposed by basement geology, namely that the basement below the Cape Nares carbonate belt is Pearyan in origin, suggest that the original position of the Cape Nares carbonate belt probably would not have been much farther east than Phillips Inlet or Yelverton Bay, about 150 km distant. Outliers of Nansen Formation are present south of Phillips Inlet and Yelverton Bay and the northern marginal belt could be projected northwestward in the direction of Milne and Ayles fiords (Fig. 5). In that case, the Nansen and Borup Fiord formations of the Cape Nares belt would have moved eastward along the Parr Bay Fault (Trettin, 1987), from an original position southwest and basinward of the marginal belt to a present position north of the marginal belt.

The second solution is preferred here. It takes into account the directional data from the northwestern marginal belt, and its paleogeographic implications are similar to those from the Assistance Formation and Mesozoic formations (Embry, in press). Other strike-slip zones are known from northern Ellesmere Island (e.g., the Porter Bay Fault Zone) and the Parr Bay Fault (Trettin, 1987) provides a convenient fault along which to move the Cape Nares carbonate belt. Also, intuitively, a source area limited to the north by the Cape Nares carbonate belt may have been too narrow to provide the substantial thickness of Canyon Fiord Formation deposited in the northwestern marginal belt.

PERMIAN FORMATIONS

Sabine Bay Formation

Definition. The name Sabine Bay Formation was originally given by Tozer and Thorsteinsson (1964, p. 101) to a rock unit on Melville Island consisting of carbonate rocks in the lower part and sandstone in the upper. Subsequent information from Ellesmere and Axel Heiberg islands necessitated a revision of the original definition, and now the name is used only for the upper, sandstone part of the original rock unit. The lower carbonate member has been reassigned to the Belcher Channel Formation (Tozer and Thorsteinsson, 1964, p. 229). Thorsteinsson (1974) extended the range of the Sabine Bay Formation to central Ellesmere Island, where the formation disconformably overlies carbonates belonging to the Belcher Channel or Tanquary formations, and is in turn overlain disconformably by the Assistance Formation. The formation occurs only along the southern and eastern margin of Sverdrup Basin. On northern Ellesmere Island, Nassichuk and Christie (1969) mapped the formation in the vicinity of the head of Tanquary Fiord and reported that it extended as far northeastward as Henrietta Nesmith Glacier.

Distribution, thickness, and contact relationships. Outcrop areas of the Sabine Bay Formation in the project area are relatively small. The formation is exposed along the south side of Rollrock River and in the footwall of the Lake Hazen Fault Zone west of Lewis River. East of Lewis River it is known only from the nunataks in the upper regions of Henrietta Nesmith Glacier (Fig. 35).

On Hamilton Peninsula the formation thins north or northwestward, from 193 m, to 27 m on the north side of Greely Fiord (Thorsteinsson, 1974). A similar thinning normal to regional strike probably takes place in the Tanquary Fiord–Lake Hazen area. Maximum incomplete thickness is 139 m south of Macdonald River (Field Station 3). Total thickness at Henrietta Nesmith Glacier is about 28 m (Fig. 35). Near Red Rock Creek (Field Station 16), a complete thickness of 100 m was measured.

The lower boundary of the Sabine Bay Formation is a disconformity with considerable pre-Sabine Bay erosion. At Henrietta Nesmith Glacier, the age of the underlying Belcher Channel Formation is early Artinskian (GSC loc. C-69894, Appendix 3), whereas at the head of Tanquary Fiord the age of the uppermost Belcher Channel Formation is early Sakmarian (GSC loc. C-45499, Appendix 3). The post early Sakmarian strata at Henrietta Nesmith Glacier (Section D), which are missing at the head of Tanquary Fiord, are in the order of 400 m thick. The upper boundary of the Sabine Bay Formation may also be an erosional disconformity. At the head of Tanquary Fiord (Field Station 4) the Sabine Bay Formation contains a nonmarine upper member. This member is missing at Henrietta Nesmith Glacier.

Lithology. Two members can be distinguished in the Sabine Bay Formation, a lower sandstone member, and an upper member consisting of shale, siltstone and pedogenic carbonates. The contact between the two members is gradational.

The Lower member is up to 110 m thick and consists of white or light grey sandstone (Fig. 35). The sandstone is fine and very fine grained, thick bedded to massive, and consists of quartzarenite. Grains are generally well rounded and sorted and nonquartz grains do not exceed 5 per cent, except in the upper part of the member. Grazing trails and herringbone crossbeds are present in the uppermost part of the member.

The Upper member is poorly exposed. About 100 m are present below the pre-Triassic unconformity at Field Station 4. The member consists primarily of siltstone and shale, which are variably grey-green and maroon coloured. Coarse grained, crossbedded sandstone is present in the uppermost part of the member. The shale-siltstone intervals contain a large number of calcrete zones similar to those described by Wright (1982), and are composed of aphanocrystalline pisolites and pelletoids or irregularly ("swirly") laminated dolomite. Cement and vug filling are calcite. Nodular and fractured textures are also present. The higher part of the member contains intervals of black, carbonaceous shale.

Mode of origin. The relatively uniform character of the sandstone, bioturbation, and herringbone crossbedding imply a marine origin for the Lower member. Well sorted sands and the dominance of planar bedding features may indicate that the Lower member represents mostly a beach sand, grading upward or landward into the nonmarine muds of the Upper member. There are two lines of evidence for a nonmarine origin of the Upper member. First, the unit contains freshwater algae (GSC loc.

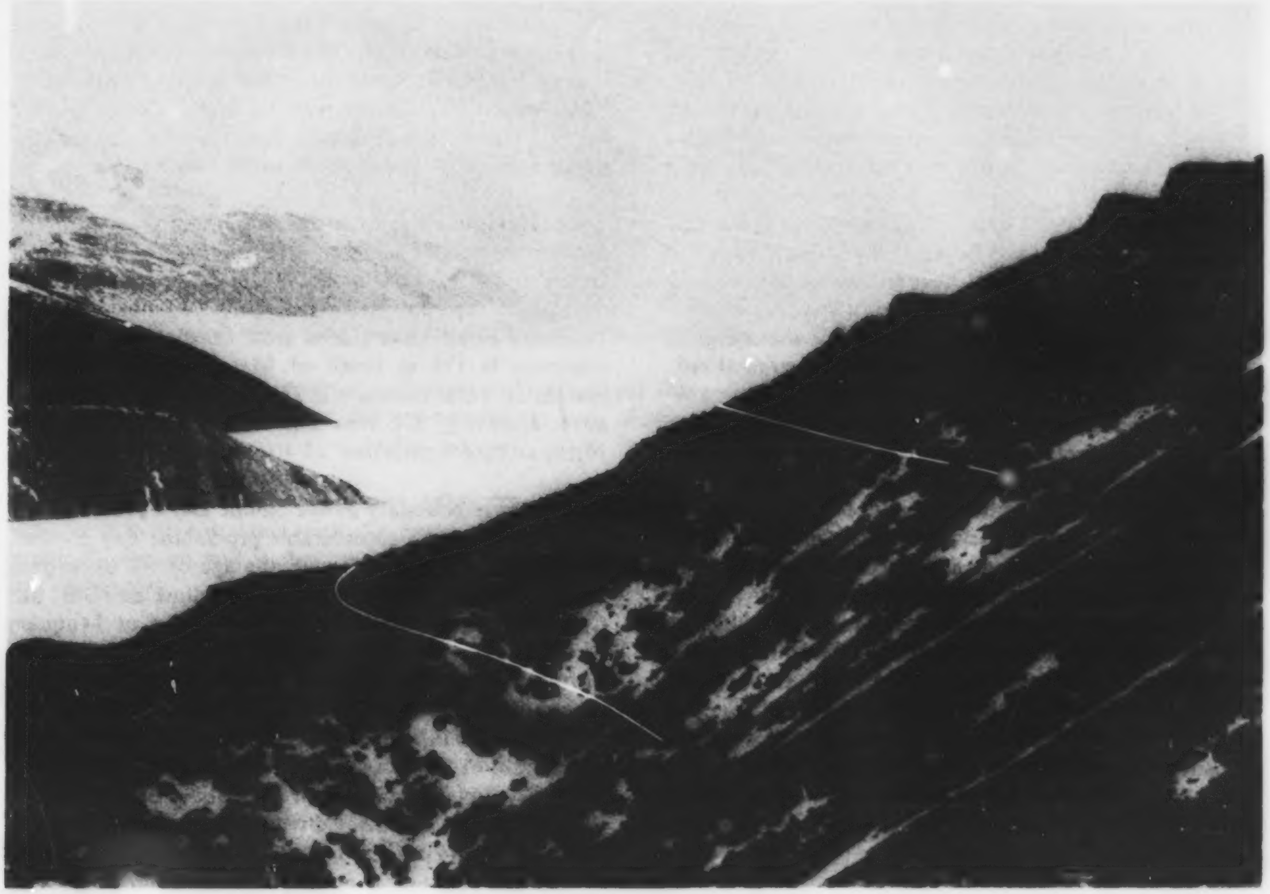


Figure 35. Thick bedded, resistant sandstone and limestone in the upper part of the Belcher Channel Formation, overlain with disconformable contact by light coloured, rubbly sandstone of the Sabine Bay Formation. The Sabine Bay Formation is about 29 m thick. The Sabine Bay Formation in turn is overlain with disconformable contact by the Assistance Formation, which consists of very fossiliferous, thin bedded siltstone and sandstone. Upper part of Section D at the upper part of Henrietta Nesmith Glacier. ISPG photo. 972-13.

C-45170); second, calcrete and pisolites, present in the unit, form in the soil under semiarid conditions. The predominantly fine grained nature of the upper member may indicate origin in a marsh area behind the beach; the sandstone beds may have been deposited in tidal creeks.

Age. No fossils of biostratigraphic value were found in the Lower member of the Sabine Bay Formation. The Upper member yielded palynomorphs of Artinskian to Roadian age (GSC loc. C-45170, Appendix 3).

The lower age of the Sabine Bay Formation is constrained by the early Artinskian age of the underlying Belcher Channel Formation at Henrietta Nesmith Glacier. The overlying Assistance Formation is also of Artinskian age, thus restricting the age of the Sabine Bay Formation to Artinskian.

Assistance Formation

Definition. Harker and Thorsteinsson (1960) proposed the name Assistance Formation for about 60 m of sandy clay and argillaceous sand. The type section is on northern Grinnell Peninsula. In this area, the Assistance Formation disconformably overlies the upper, recessive and sandy part of the Belcher Channel Formation of Harker and Thorsteinsson (1960), now considered to be a separate, but not yet formally defined formation (C.M. Henderson and B. Beauchamp, pers. comm., 1987). The new, unnamed formation is of late Sakmarian and Artinskian age (Nassichuk and Wilde, 1977); the Assistance Formation is of late Artinskian/Roadian age.

On Melville Island, Grinnell Peninsula, and in the vicinity of Canyon Fiord, the Assistance Formation is of late Artinskian age. On Bjorne Peninsula, the formation is of early Artinskian age. Thorsteinsson (1974) interpreted this discrepancy as the result of overstepping of the formation from the deeper parts of Sverdrup Basin onto the margin, or, alternatively, as an indication of a different formation on Bjorne Peniunsula. Nassichuk and Wilde (1977) expanded on the latter explanation. They interpreted the older "Assistance Formation" of Bjorne Peninsula as a new formation, equivalent to the recessive, upper portion of the Belcher Channel Formation, now a new, unnamed formation.

Thorsteinsson (1974) also defined the van Hauen Formation. This unit consists typically of two members. Member A (lower) is recessive, and consists of dark grey to black shale, and siltstone. Member B (upper) comprises a uniform succession of dark grey or black chert and siliceous siltstone. The van Hauen Formation is the facies equivalent of the Sabine Bay, Assistance, Trold, and Degerböls formations in the basinal areas of Sverdrup Basin (Beauchamp et al., 1989b).

On northern Ellesmere Island, lithological features similar to those of the Assistance and the van Hauen formations are present, but the interval under discussion appears to be represented at a number of localities by facies intermediate between the typical developments of both formations. For reasons of simplicity, all rocks have been assigned arbitrarily to the Assistance Formation, but different lithofacies can be distinguished.

Rocks in northern Ellesmere Island, now assigned to the Assistance Formation, were first mentioned by Feilden and de Rance (1878) who called them the Dana Bay Beds (Table 2) but did not give any lithological descriptions. They considered them to be of Devonian age and to underlie the main Carboniferous-Permian sequence. Holtedahl (1929) reassigned a Carboniferous age to Feilden and de Rance's collections. Blackadar (1954) described the Dana Bay "group" as grey limestone and black, argillaceous limestone, and also noted the strong structural deformation of the unit. A possible Early Permian age was assigned to his fossil collections and he placed the Dana Bay "group", with possible angular unconformity, stratigraphically below units now known to be the Canyon Fiord and Belcher Channel formations. Mapping during this project has shown that the Dana Bay Beds (Assistance Formation) are preserved in a tectonic graben and are separated by major faults from the apparently overlying Carboniferous units. Christie (1957) reported the presence of chert and limy shale with brachiopods and corals at Markham Fiord. These units are now included in the Assistance Formation.

Distribution, thickness, and contact relationships. In the southernmost part of the project area, the formation is present only at Henrietta Nesmith Glacier (Fig. 20) where it is about 210 m thick. In the northern part it is discontinuously exposed in the Feilden Peninsula area, on the northwest side of Clements Markham Inlet, at central Markham Fiord, and at the heads of M'Clintock Inlet and Yelverton Inlet. Thicknesses are variable. At M'Clintock Inlet, the Assistance Formation (Section H) is overlain by Triassic sandstone and the total thickness is 144 m; at Markham Fiord, the thickness exceeds 200 m. On the southwest side of Yelverton Inlet, the estimated thickness is 150 m and the formation is overlain directly by Triassic rocks. On the northeast side the thickness may be somewhat greater. Beds assigned to the Assistance Formation at Yelverton Pass are 3.5 m thick.

The lower boundary of the formation is a disconformity (see the section on the Sabine Bay Formation).

The upper boundary is sharp and also a disconformity. At the southern entrance to Piper Pass, the overlying Trold Fiord Formation lies directly on folded lower Paleozoic basement, whereas 50 to 60 km to the west at Henrietta Nesmith Glacier, at least 1300 m of Carboniferous and Permian strata, mostly marine units, are present between the basement and the Trold Fiord Formation. This large discrepancy in thickness over a distance of less than 60 km probably indicates a phase of faulting and erosion prior to the deposition of the Trold Fiord Formation.

Lithology. Three major types of lithofacies can be distinguished in the Assistance Formation: a dark coloured, recessive shale and chert lithofacies; a lighter coloured, calcareous sandstone lithofacies; and a maroon sandstone and conglomerate facies.

Where present, the shale–chert lithofacies forms the lower part of the formation. It is a recessive interval and is generally poorly exposed. In the northeastern part of the project area, at Parker River (Section I) and Markham Fiord (Section O), the lithofacies is about 100 m thick, and the boundary with the overlying part of the formation is gradational. It is not present at Henrietta Nesmith Glacier and in the M'Clintock Inlet area. The lithofacies is also prominent around the head of Yelverton Inlet where it is estimated to be at least 150 m thick, but it is not present in Section E1. The lithofacies comprises very dark coloured shale, siltstone, chert and limestone. Siltstone and chert are more common in the northeastern part of the project area, whereas shale and limestone predominate at the head of Yelverton Inlet (Field Station 9). The siltstone is variably calcareous or cherty and commonly contains brachiopods and other fossils. The chert intervals locally contain concentrations of sponge spicules. The limestone consists either of massive beds of very coarse, bioclastic packstone, or of argillaceous, locally nodular, thin bedded lime mudstone interbedded with shale. Dominant bioclastic components are brachiopod and bryozoan fragments.

The calcareous sandstone lithofacies consists predominantly of thin bedded, medium to dark grey, very fine grained lithic greywacke with carbonate lithoclasts (Fig. 35). Ripple marks or crossbedding appear to be absent. Feldspar, mica or other weathered clasts are rare. The sandstone is interbedded with minor skeletal grainstone or packstone, which consists mostly of bryozoan fragments. A few interbeds of brachiopod coquina are also present. The sandstone contains abundant vertical and horizontal burrows and *Zoophycus* sp.

The sandstone–conglomerate lithofacies was seen only at Markham Fiord in the upper part of the formation (Section N, Fig. 21). There, the lowermost 32 m or so of the lithofacies, overlying the black shale and chert, consist of green shale and very fine grained sandstone similar to that in the sandstone lithofacies. The remaining 104 m consist of interbedded sandstone, conglomeratic sandstone, conglomerate, siltstone, and shale. The dominant colour of this interval is maroon. In the lower part, the various lithotypes are arranged in fining-upward cycles; individual cycle thicknesses vary from one to nine metres, and conglomerates of white chert form the bases of the cycles. The upper part of the section consists of medium to thick bedded sandstone, in part with abundant trough crossbeds, and with minor interbeds of siltstone and shale. Most of the sandstone has an arkosic composition. The proportion of K-feldspars is slightly higher than that of plagioclase. Minor constituents are carbonate lithoclasts, chlorite and micas.

About 3 km inland from Section N, massive conglomerate with a maximum pebble diameter of 12 cm occurs in the core of a small syncline. These beds are stratigraphically higher than the top of Section N and may be part of the Assistance Formation.

Red sandstones were also observed in scree at M'Clintock Inlet, but they appear to form only a very small part of the Assistance Formation. The formation is poorly exposed there and probably consists mostly of thin bedded, sandy and silty limestone. In the region at the head of Yelverton Inlet and de Vries Glacier some brick red, sandy carbonates are present, probably in the upper part of the formation.

Mode of origin. The Assistance Formation is a shallowing-upward sequence. The dark shale, chert and thin bedded carbonate at the base of the formation are basin slope deposits, deposited when sea level was highest. The calcareous sandstone lithofacies is of shallower origin than the underlying shale and chert lithofacies. The lack of ripple crosslamination and the very fine grained nature of the sandstone show, however, that this lithofacies was still deposited below wave base. Rocks that could be interpreted as being of shallow marine, above wave base origin, were not observed in the Assistance Formation.

The red colour, absence of marine fossils, fining-upward cycles, and the conglomerates of the sandstone–conglomerate lithofacies indicate a nonmarine, fluvial environment of deposition.

Age and correlation. A number of brachiopod collections from the Assistance Formation on northern Ellesmere Island were identified and dated. B.R. Wardlaw assigned a Roadian age to collections from Henrietta Nesmith Glacier (GSC locs. C-82539 and C-82555, Appendix 3), while Z. Liao is less definite in age assignment (GSC locs. C-45394, C-45466, C-83473 and C-99547, Appendix 3) but quite definite in his opinion that these faunas belong to the upper Assistance Formation or even Trold Fiord Formation. The unnamed formation of Nassichuk and Wilde (1977) is mostly of early Artinskian age; thus, the units here assigned to the Assistance Formation correlate with the Assistance Formation of the type section but not with the unnamed formation.

Trold Fiord Formation

Introduction. The name Trold Fiord was proposed by Thorsteinsson (1974) for a formation that consists chiefly of sandstone. Subordinate limestone, pebble conglomerate and chert are also present. A green weathering colour in outcrop is characteristic. The type section is in the vicinity of Cañon Fiord, where the formation is about 110 m thick. Thickness of the formation is variable and the unit is restricted to the southern and western margins of Sverdrup Basin. Basinward, the formation correlates with the limestone and chert of the Degerböls Formation. At the type section the Trold Fiord Formation overlies the Assistance Formation and is in turn overlain by Triassic units. The nearest occurrences to the project area were mapped by Thorsteinsson (1974) and are located along the west side of Tanquary Fiord, where the formation is about 85 m thick and consists of medium bedded, calcareous sandstone.

Nassichuk and Christie (1969) described an occurrence of Trold Fiord Formation from a locality 16 km northwest of Yelverton Lake. At this locality the formation consists of about 60 m of fossiliferous limestone with minor interbeds of pale green weathering, fine grained sandstone. The northern part of the shale and sandstone occurrences that were reported by Christie

Figure 36. Light coloured strata of the Trold Formation, consisting of relatively pure sandstone, directly overlying dark coloured, folded, lower Paleozoic rocks. Height of slope is about 400 m. South part of Piper Pass, near Locality B of Miall (1978). ISPG photo. 2525-3.

(1964, p. 42) from the south end of Piper Pass are now assigned to the Trold Fiord Formation.

Distribution, thickness, and contact relationships. The Trold Fiord Formation is present along the southeastern margin of the project area, and was examined at Henrietta Nesmith Glacier (Section D) and at the south end of Piper Pass (Miall, 1978). Thickness of the formation along this belt is in the order of 500 m.

The lower and upper boundaries of the formation are sharp and unconformable. At Henrietta Nesmith Glacier it overlies the Assistance Formation with sharp contact, whereas, at Piper Pass, the Trold Fiord Formation lies directly on folded lower Paleozoic rocks (Fig. 36). At Henrietta Nesmith Glacier the boundary was drawn below a pink weathering, rather mature sandstone, immediately above the highest argillaceous and calcareous sandstone of the Assistance Formation. The upper boundary is a disconformity, with Triassic rocks, at Henrietta Nesmith Glacier.

Lithology. The dominant lithology of the Trold Fiord Formation is light coloured, thick bedded quartzarenite. The sandstone is mature and fine grained, rarely very fine or medium grained. Conglomeratic intervals are present in the lower part of the formation. The sandstone consists almost entirely of quartz. Chert and feldspar are of secondary importance and do not exceed 5 per cent. The cement is commonly quartz, but in some intervals calcite cement is present. In parts of the section the sandstone is poorly consolidated. In the lower part of the formation, some interbeds containing abundant skeletal debris are present. Most of the sandstone is massive, but in the lower part the Trold Fiord Formation also exhibits crossbedding and bioturbation, with abundant *Zoophycos* sp.

Figure 37. Recessive weathering chert of the Degerböls Formation forms the dip slope at the right side of the photograph and is overthrust by lower Paleozoic volcanic rocks. In foreground is the thick bedded limestone of the underlying Belcher Channel Formation. Upper part of Section N near head of Markham Fiord. ISPG photo. 972-68.

Mode of origin. The Trold Fiord Formation is of shallow marine origin. Miall (1978) suggested, on the basis of low-angle crossbedding and herringbone crossbedding, an intertidal, shallow coastal environment for the clean sandstone in the southeastern part of the area at Piper Pass, and a more seaward, open environment for the more calcareous lithotypes.

Age and correlation. Several brachiopod faunas from Piper Pass and Henrietta Nesmith Glacier (Appendix 3, GSC locs. C-68635, C-68637, C-82567) indicate a Wordian age for the Trold Fiord Formation in northeastern Ellesmere Island. This is the same age reported by Thorsteinsson (1974) from Hamilton Peninsula. The Trold Fiord Formation correlates with the Degerböls Formation.

Degerböls Formation

Definition. The name Degerböls Formation was proposed by Thorsteinsson (1974) for a unit of resistant carbonate rocks in northeastern Ellesmere and northern Axel Heiberg islands, which, like the Trold Fiord Formation, forms the top of the Permian succession. It consists mainly of interbedded coarse and fine grained limestone. Chert nodules and chert beds are common throughout the unit. Locally, the formation consists almost entirely of chert. The largest preserved thickness is about 400 m, on western Axel Heiberg Island.

Distribution, thickness, and contact relationships. In northern Ellesmere Island the formation is present at the head of Markham Fiord. It is estimated to be about 235 m thick. The lower contact is disconformable and the formation lies directly on the Belcher Channel Formation; the Assistance Formation is missing. The upper contact is a thrust with lower Paleozoic volcanic rocks in the hanging wall. Also tentatively assigned to the Degerböls Formation are 230 m of limestone at the top of Section E1 on the north side of de Vries Glacier (Figs. 26, 39). The formation may also be present at the head of M'Clintock Inlet.

Figure 38. Brachiopod coquina forming the lower part of the Degerböls Formation near the head of Markham Fiord. Unit 56, Section N, GSC loc. C-70008. ISPG photo. 972-70.

Lithology. The section at Markham Fiord (Section N) is poorly exposed (Fig. 37). The lower part consists of light coloured, recessive weathering chert with rare *Zoophycus* sp. Sponge spicules and traces of glauconite are contained in the chert. The chert is overlain by very coarse grained skeletal lime-packstone and brachiopod coquina (Fig. 38). Rocks of the interval are very light grey to brown and thick bedded. The upper part of the formation consists of thin bedded, very dark grey chert interbedded with dolomitic and argillaceous lime mudstone.

The lithology of the Degerböls Formation in the M'Clintock Inlet area is somewhat different. There, the formation consists of limestone, chert and sandstone. The exposures are within a complex fault zone and no detailed examination was made. The thickness is presumably very small because in Section H, only three kilometres to the east, the Assistance Formation is overlain directly by Triassic sandstone. The uppermost unit of Section E1 (Unit 19) consists mainly of thick bedded skeletal grainstone interbedded with chert (Fig. 39). This unit is tentatively assigned to the Degerböls Formation.

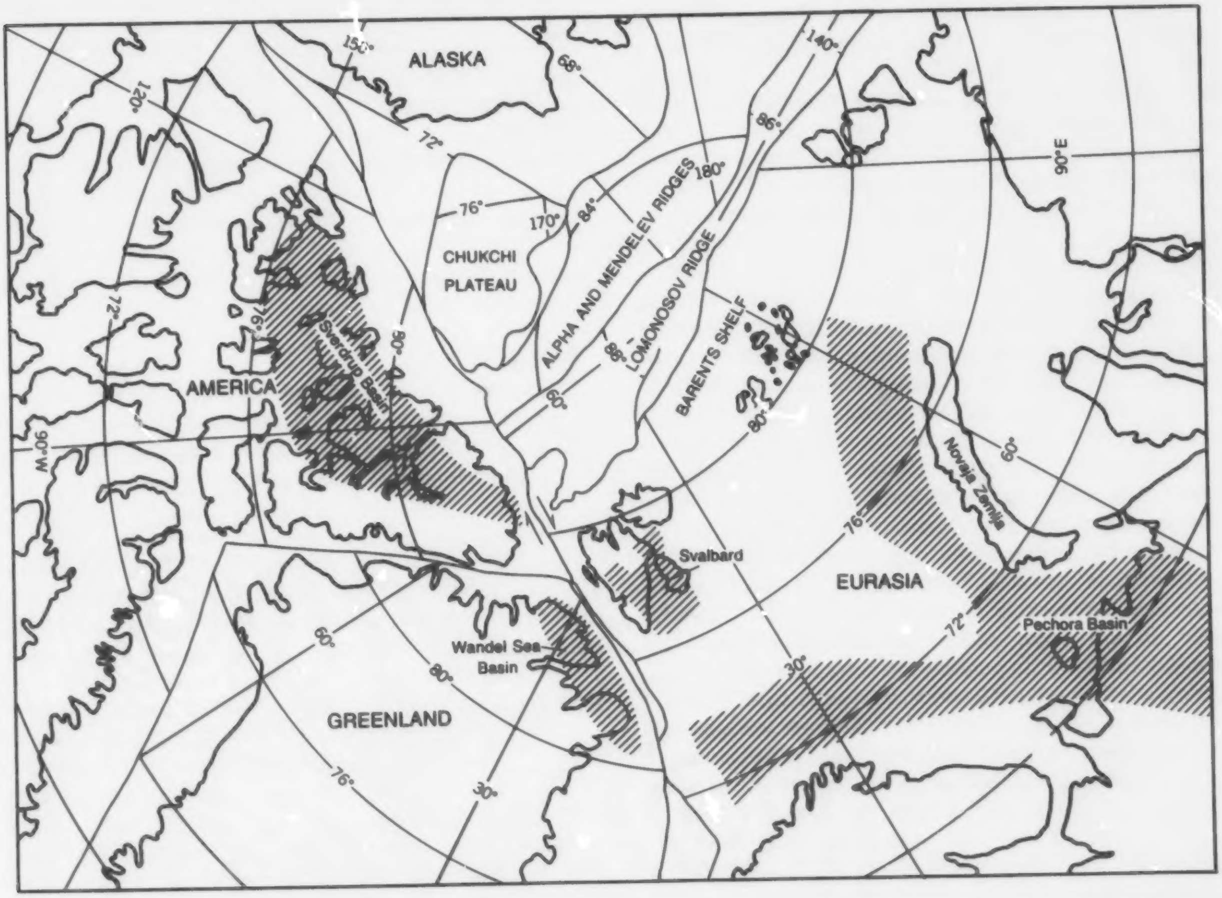
Mode of origin. The Degerböls Formation represents a transition from shallow water shelf rocks to deeper water lithotypes. The lower, light coloured chert and the brachiopod coquinas probably formed above or at wave base, and the dark chert and argillaceous limestone of the upper part indicate deposition below wave base.

Age and correlation. Faunas from the brachiopod coquina in Section N (Appendix 3, GSC loc. C-70008) and from the head of M'Clintock Inlet (GSC loc. C-99579) indicate a Wordian age. The Degerböls Formation correlates with the Trold Fiord Formation.

Figure 39. Thin bedded chert and limestone, possibly belonging to the Degerböls Formation, in Unit 19 of Section E1 at de Vries Glacier (compare Figure 26). The nunataks in the background consist of thick bedded dolomite belonging to the Nansen Formation and conglomerate and sandstone of the Borup Fiord Formation. ISPG photo. 2525-2.

CONCLUSIONS AND SPECULATIONS

The Carboniferous and Permian formations of Sverdrup Basin and northern Ellesmere Island are part of a depositional regime that was also present in the Wandel Basin in northeastern Greenland and on Svalbard and Bear Island. Plate reconstruction based on closed Arctic and North Altantic oceans (Fig. 40) places these areas in close juxtaposition. Harland et al. (1984) speculated on a pattern of plate margins, and motions between North America and Europe, for the North Atlantic and the northern margins of the North American continent. According to these authors, post-Caledonian plate movements may have been more or less continuous, but they identified two main phases. A Late Devonian phase would have caused sinistral strike-slip movement along the northern plate margin and would have been part of the Ellesmerian Orogeny; a second sinistral strike-slip phase took place during late Early Carboniferous. These two phases of strong movement were followed by a stable phase of relatively little movement, lasting from Late Carboniferous to Triassic. Svalbard at that time was positioned north of Greenland, relatively close to the Wandel Basin and northern Ellesmere Island. These north Atlantic events match somewhat the depositional history of northern Ellesmere Island, where nonmarine and evaporitic sediments were deposited during Viséan and Namurian in local basins (the second sinistral phase of Harland et al., 1984), and more extensive shallow water carbonates formed on a stable shelf during the Late



ALASKA
150°
68°
140°
120°
72°
86°
180°
90°E
76°
170°
84°
CHUKCHI
PLATEAU
ALPHA AND MENDELEV RIDGES
LOMONOSOV RIDGE
72°
76°
Sverdrup Basin
90°
88°
BARENTS SHELF
AMERICA
60°
80°
90°W
Novaja Zemlja
60°
76°
Svalbard
EURASIA
60°
Wandel Sea Basin
80°
72°
Pechora Basin
30°
GREENLAND
76°
30°

Figure 40. Map showing the relationships of northern Ellesmere Island, Svalbard and the Wandel Sea Basin during the late Paleozoic and the geographic proximity of these three areas. Cretaceous and Tertiary opening of the North Atlantic between Greenland and Norway, and of the Arctic Ocean along the Nansen Ridge between the Lomonosov Ridge and the Barents Shelf, resulted in the dextral strike-slip movements north of Ellesmere Island that also may have affected the Parr Bay Fault and the Porter Bay Fault Zone on northern Ellesmere Island. (Modified from Steel and Worsley, 1984.)

Carboniferous and Permian (the stable phase of Harland et al., 1984).

Either strike-slip movements or simple initial rifting during the Early Carboniferous could have produced a complex system of small local basins and horsts. Aydin and Page (1984) described the diverse tectonics associated with strike-slip movements along a diffuse plate boundary. Pull-apart basins of various diameters and with normal fault scarps are common. Rifting without an apparent strike-slip component will also produce a complex pattern of grabens and ridges. Rosendahl et al. (1986) studied Lake Tanganyika, in the West African rift system. The lake consists of a series of arcuate half-grabens, which are separated by interbasinal ridges and face in opposite directions. Sediments enter the lake as conglomerates and fanglomerates along the border faults or from the shoaling side of the half-grabens. Additional sediments are carried in by a major river in a direction subparallel to the border faults. Initial rifting of Sverdrup Basin during Early Carboniferous and early Late Carboniferous (Emma Fiord and Borup Fiord formations) in northern Ellesmere Island, and probably elsewhere in the basin, has to be seen in the context of one or both of the two tectonic examples mentioned above.

There appear to be a number of similarities between early Sverdrup Basin deposition in northern Ellesmere Island and late Paleozoic deposition on Svalbard (Steel and Worsley, 1984). The Viséan sequence on Svalbard was deposited in a narrow graben and consists of nonmarine, coal-bearing strata comparable to the Emma Fiord Formation. During the Namurian–Bashkirian, the overall depositional area widened but contained local horsts and grabens. The succession is similar to that of the Borup Fiord Formation and comprises alluvial fan and floodplain deposits. Thicknesses of several thousand metres are comparable to those on northern Ellesmere Island. In part, these sediments were deposited in basins arranged en echelon, possibly reflecting an oblique-slip tectonic regime. Post-Bashkirian similarities between Svalbard and northern Ellesmere Island are tenuous. On northern Ellesmere Island a broad, deep basin developed during the Moscovian, whereas, on Svalbard, deep water sedimentation did not occur until the Early Permian.

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APPENDIX 1

Index of Field Stations

Field Station	Coordinates	NTS grid	Map sheet	Remarks
1	81°26.95′N 76°27′W	9043600 m N 475950 m E	Tanquary Fiord	4.5 km east of head of Tanquary Fiord
2	81°23.64′N 76°26′W	9037300 m N 476050 m E	Tanquary Fiord	South side of Macdonald River, 8.3 km from mouth
3	81°23.51′N 76°30′W	9037150 m N 475000 m E	Tanquary Fiord	South side of Macdonald River, 7.6 km from mouth
4	81°25.26′N 76°18′W	9040400 m N 478500 m E	Tanquary Fiord	7.3 km east of head of Tanquary Fiord
5	81°34.93′N 76°48′W	9059200 m N 453450 m E	Tanquary Fiord	Section P, 7 km southeast of Yelverton Lake
6	81°32.73′N 76°48′W	9055100 m N 455100 m E	Tanquary Fiord	10.5 km southwest of Yelverton Lake
7	81°41.14′N 78°15′W	9070650 m N 544450 m E	Tanquary Fiord	Section A, north side of Yelverton Pass
8	81°54.59′N 79°24′W	9095050 m N 525050 m E	Tanquary Fiord	Units 1-126 of Section E3, northeast side of head of Yelverton Inlet
9	81°49.98′N 79°39′W	9088900 m N 521400 m E	Tanquary Fiord	Southwest side of head of Yelverton Inlet
10	81°47.97′N 79°40′W	9085050 m N 520100 m E	Tanquary Fiord	5 km south of head of Yelverton Inlet
11	81°53.10′N 79°17′W	9092500 m N 526950 m E	Tanquary Fiord	Units 127-216 of Section E3, northeast side of head of Yelverton Inlet
12	81°56.72′N 79°12′W	9099150 m N 529300 m E	Tanquary Fiord	Southwest side of de Vries Glacier
13	81°50.33′N 78°24′W	9087550 m N 536950 m E	Tanquary Fiord	Southwest side of de Vries Glacier
14	81°55.29′N 78°38′W	9096700 m N 537300 m E	Tanquary Fiord	Top of Section E1, northeast side de Vries Glacier
15	81°38.78′N 78°31′W	9066000 m N 524100 m E	Tanquary Fiord	Southwest side of Yelverton Pass
16	81°27.08′N 76°33′W	9043800 m N 475200 m E	Tanquary Fiord	3.8 km east of head of Tanquary Fiord
17	81°55.13′N 73°05′W	9096250 m N 530250 m E	Tanquary Fiord	East side of upper Henrietta Nesmith Glacier
18	81°57.83′N 73°11′W	9101100 m N 528300 m E	Tanquary Fiord	Units 1-24 of Section D, east side of upper Henrietta Nesmith Glacier
19	81°56.88′N 73°14′W	9099300 m N 527550 m E	Tanquary Fiord	Units 25-39 of Section D, east side of upper Henrietta Nesmith Glacier
20	72°7.93′N 75°17′W	9119550 m N 496650 m E	M'Clintock Inlet	Uppermost part of M'Clintock Glacier
21	82°16.53′N 75°35′W	9135550 m N 491350 m E	M'Clintock Inlet	East side of upper M'Clintock Glacier
22	82°16.53′N 75°35′W	9135550 m N 491350 m E	M'Clintock Inlet	East side of upper M'Clintock Glacier
23	82°15.73′N 75°35′W	9134100 m N 4915050 m E	M'Clintock Inlet	East side of upper M'Clintock Glacier
24	82°15.07′N 75°31′W	9132800 m N 492250 m E	M'Clintock Inlet	Units 1-51 of Section F3, east side of upper M'Clintock Glacier

Field Station	Coordinates	NTS grid	Map sheet	Remarks
25	82°14.98′N 75°31′W	9132300 m N 4922300 m E	M'Clintock Inlet	Unit 52 of Section F3, east side of upper M'Clintock Glacier
26	82°14.12′N 75°25′W	9131100 m N 494100 m E	M'Clintock Inlet	Section F2, east side of upper M'Clintock Glacier
27	82°13.85′N 75°26′W	9130600 m N 493800 m E	M'Clintock Inlet	Units 1-19 of Section F, east side of upper M'Clintock Glacier
28	82°13.85′N 75°26′W	9130600 m N 493800 m E	M'Clintock Inlet	East side of upper M'Clintock Glacier
29	82°51.95′N 71°10′W	9202050 m N 469850 m E	Clements Markham Inlet	Top of Section N, 3.8 km southwest of head of Markham Fiord
30	82°49.13′N 65°37′W	9196300 m N 463400 m E	Clements Markham Inlet	West side of Parker Bay
31	82°49.82′N 65°28′W	9197200 m N 465650 m E	Clements Markham Inlet	West side of Parker Bay
32	82°48.37′N 71°48′W	9196100 m N 468900 m E	Clements Markham Inlet	Base of Section N, 7.5 km southwest of head of Markham Fiord
33	82°27.35′N 64°30′W	9156200 m N 494700 m E	Clements Markham Inlet	Units 50-96, Section K, east side of upper Clements Markham River
34	81°52.97′N 76°49′W	9092200 m N 471000 m E	Tanquary Fiord	Upper part of de Vries Glacier
35	81°54.21′N 77°15′W	9097080 m N 464700 m E	Tanquary Fiord	Upper part of de Vries Glacier
36	82°38.37′N 64°34′W	9176150 m N 494125 m E	Clements Markham Inlet	Section M, 10.3 km west of head of Clements Markham Inlet
37	82°53.86′N 64°46′W	9205500 m N 475550 m E	Clements Markham Inlet	Section C, 1.5 km southeast of Cape Hecla
38	82°48.38′N 65°17′W	9195500 m N 468000 m E	Clements Markham Inlet	East side of Parker Bay
39	82°35.33′N 68°40′W	9170650 m N 504500 m E	Clements Markham Inlet	Section L2, 3.8 km south of head of Clements Markham Inlet
40	81°55.89′N 79°05′W	9097650 m N 529700 m E	Tanquary Fiord	Section E2, southwest side of de Vries Glacier
41	82°22.49′N 75°44′W	9146650 m N 489200 m E	M'Clintock Inlet	Section G, east side of middle part of M'Clintock Glacier
42	82°32.30′N 75°05′W	9164900 m N 499000 m E	M'Clintock Inlet	10.8 km east of head of M'Clintock Inlet
43	82°13.72′N 75°19′W	9130250 m N 495600 m E	M'Clintock Inlet	Units 20-46 of Section F1, east side of upper M'Clintock Glacier
44	82°26.49′N 69°30′W	9154100 m N 493100 m E	Clements Markham Inlet	Units 1-49 of Section K, east side of upper Clements Markham River
45	82°27.69′N 69°25′W	9156250 m N 494450 m E	Clements Markham Inlet	Section L1, east side of upper Clements Markham River
46	82°24.17′N 70°51′W	9149000 m N 473000 m E	Clements Markham Inlet	41 km southwest of head of Clements Markham Inlet (Location 19 of Christie, 1964)
47	82°42.08′N 65°15′W	9183850 m N 467400 m E	Clements Markham Inlet	Units 1-10 of Section I, 5.7 km southwest of head of Parker Bay
48	82°41.75′N 65°15′W	9183300 m N 467375 m E	Clements Markham Inlet	Units 11-19 of Section I, 6.2 km southwest of head of Parker Bay
49	81°54.31′N 73°43′W	9094400 m N 520000 m E	Tanquary Fiord	West side of upper Henrietta Nesmith Glacier
50	81°55.13′N 78°42′W	9096450 m N 536125 m E	Tanquary Fiord	Base of Section E1, northeast side of de Vries Glacier

Field Station	Coordinates	NTS grid	Map sheet	Remarks
51	82°59.20′N 71°40′W	9215750 m N 463650 m E	Clements Markham Inlet	Lower part of Section O, west side of central Markham Fiord
52	82°58.78′N 71°40′W	9214950 m N 463600 m E	Clements Markham Inlet	Upper part of Section P, west side of central Markham Fiord
53	82°38.97′N 74°49′W	9177300 m N 502500 m E	M'Clintock Inlet	9 km northeast of head of M'Clintock Inlet
54	82°40.07′N 74°49′W	9179375 m N 502550 m E	M'Clintock Inlet	Section Q, 15 km northeast of head of M'Clintock Inlet
55	82°47.43′N 65°19′W	9193850 m N 467250 m E	Clements Markham Inlet	Section B, east side of Parker Bay
56	82°39.46′N 75°35′W	9178550 m N 493300 m E	M'Clintock Inlet	4 km north of river mouth at east side of head of M'Clintock Inlet

APPENDIX 2

Descriptions of stratigraphic sections

SECTION A

This section is situated in cliffs on the north side of Yelverton Pass (Field Station 7), and was described and measured by Ulrich Mayr and J. Calvert.

Overlying beds Triassic, contact slight angular unconformity

Okse Bay Formation
(Devonian)

Unit	Lithology	Thickness (m) Unit	Thickness (m) Total from base
	Upper member		
115	**Sandy conglomerate, conglomeratic sandstone**, and **medium grained sandstone** (interbedded). 4 cm maximum pebble diameter; medium to thick bedded, crossbedded; thin lenses and partings of green shale; sandstone quartzitic, estimated 30% chert	112.5	592.5
114	**Shale:** silty; maroon; sandstone pillows; shale, laterally discontinuous	1.5	480.0
113	**Sandstone** and **sandy conglomerate**: white-rusty; as are Unit 115 and Units 78 to 112	56.0	478.5
112	**Sandstone:** white with brown specks; fine to medium grained; thin bedded to laminated; sharp upper boundary	1.5	422.5
111	**Conglomerate:** 4.5 cm maximum pebble diameter; massive; upper boundary gradational	4.0	421.0
110	**Sandstone:** limonitic; white to pink-brown; medium grained; thin bedded, trough crossbeds	1.0	417.0
109	**Conglomerate:** white; 4.5 cm maximum pebble diameter; massive; zones of crossbedded, medium grained sandstone	2.5	416.0
108	**Sandstone:** white to light pink; medium grained; thin bedded, planar tabular crossbeds	1.0	413.5
107	**Conglomerate:** white; 4 cm maximum pebble diameter; massive; abundant white chert, minor dark grey and lavender	8.0	412.5
106	**Sandstone:** white; medium grained; massive, planar tangential crossbeds; trace of chlorite	20.5	404.5
105	**Conglomerate:** white; 1.5 cm maximum pebble diameter; mostly white chert; gradational upper boundary	0.5	384.0
104	**Shale:** maroon and green; sharp upper boundary; poorly exposed	1.0	383.5
103	**Conglomerate:** white and grey; 4 cm maximum pebble size; massive; interbedded with sandstone with planar tangential crossbeds; basal contact of conglomerates sharp, upper contact gradational	16.0	382.5
102	**Sandstone:** light pink; medium grained; massive, tangential planar crossbeds; quartzite, estimated 20% chert; sharp upper boundary	0.5	366.5
101	**Conglomerate:** white; 2 cm maximum pebble diameter; medium to thick bedded; zones of very coarse grained sandstone; chert pebbles; upper boundary gradational	1.5	366.0
100	**Shale** and **sandstone** (interbedded)	0.5	364.5
	Shale: silty; light green	0.06	
	Sandstone: green with maroon specks; fine to medium grained; laminated	0.16	
	Shale: silty; light green	0.09	
	Shale: silty; maroon; forms small lens	0.25	
99	**Sandstone:** conglomeratic; light green-white; medium grained; thin bedded, planar crossbeds; angular, poorly sorted; 1.5 cm diameter floating chert pebbles	2.0	364.0
98	**Conglomerate:** as Unit 101	2.0	362.0
97	**Sandstone:** white; medium grained; massive	4.0	360.0
96	**Conglomerate:** white; 2 cm maximum pebble diameter; massive; mostly white chert; gradational upper boundary	0.5	356.0
95	**Sandstone:** white; medium grained; thin to medium bedded, planar tangential crossbeds; conglomeratic in uppermost part; sharp upper boundary	13.0	355.5
94	**Sandstone:** green and maroon; medium grained; thin bedded, crossbedded; interbedded with thin bedded, fine grained, maroon sandstone and maroon shale; 0.25 m of green siltstone in upper part of unit (Mineralogical analysis, GSC loc. C-45313, see Appendix 4)	3.0	342.5
93	**Sandstone:** quartzitic; white; coarse to medium grained; estimated 40% chert, angular; rubbly exposure (Mineralogical analysis, GSC loc. C-45312, see Appendix 4)	7.5	339.5
92	**Sandstone:** white; medium grained; thin to medium bedded; trace of conglomerate at base, 0.02 m green, laminated sandstone at top	5.5	332.0

Unit	Lithology	Thickness (m)	
		Unit	Total from base
91	**Sandstone:** white; coarse grained; medium to thick bedded, tabular trough crossbeds; 0.05-0.10 m laminated, green, medium grained sandstone at top	5.5	326.5
90	**Conglomerate:** white; 2 cm maximum pebble diameter; chert pebbles	0.5	321.0
89	**Sandstone:** green and maroon; very fine grained; laminated; silty laminae, uppermost 0.10 m green siltstone; estimated 50% chert; recessive	0.5	320.5
88	**Shale:** silty, micaceous; maroon; laterally discontinuous; in lower part interbedded with thin bedded siltstone and very fine grained sandstone	3.5	320.0
87	**Sandstone:** conglomeratic; white; medium grained; massive; zones of coarse grained sandstone	5.5	316.5
86	**Conglomerate:** discontinuous channel fill on Unit 85	0.0-0.6	316.5
85	**Sandstone:** white; medium grained; medium to thick bedded, planar tabular crossbeds; zones of conglomerate; 0.02 m of shale at top	1.5	311.0
84	**Conglomerate:** white; 2 cm maximum pebble diameter; vague crossbeds; zones of medium grained sandstone; mostly white chert pebbles; gradational upper boundary	3.0	309.5
83	**Sandstone:** as Unit 85	2.0	306.5
82	**Conglomerate:** as Unit 84	3.0	304.5
81	**Sandstone:** quartzitic; light white-green; medium grained; thin to medium bedded, tangential crossbeds; conglomerate zones; 2 thin beds of laminated, green, silty, medium grained sandstone, one of them at top of unit; estimated 30% chert	2.5	301.5
80	**Conglomerate:** white; 4 cm maximum pebble diameter; massive, with interval thin beds, vague crossbeds, lower boundary channelled; mostly white chert pebbles; upper boundary gradational	2.5	299.0
79	**Sandstone:** very light green-white; medium grained; conglomeratic zones; well sorted; estimated 10% white chert; poorly exposed	12.5	296.5
78	**Conglomerate:** white; 3 cm maximum pebble diameter; massive; thickness variable; roll of underlying shale (?load cast) in basal part of conglomerate.	1.5	284.0
	Lower member		
77	**Siltstone:** maroon; upper boundary sharp; poorly exposed	5.0	282.5
76	Covered: probably green shale and siltstone	8.5	277.5
75	**Sandstone:** medium green; medium grained; massive	1.5	269.0
74	Covered: probably maroon shale	11.5	267.5
73	**Siltstone:** sandy; dark brown-grey; very thin bedded; trace of coal; abundant plant fragments; palynomorphs (GSC loc. C-45307, Late Devonian, Frasnian(?), Appendix 3b)	3.0	256.0
72	Covered: probably dark green-grey, micaceous shale	18.5	253.5
71	**Sandstone:** green; medium grained; medium bedded; interbedded with maroon shale and very fine grained sandstone	2.0	235.0
70	**Sandstone:** slightly quartzitic; light grey; coarse grained; massive, planar tabular crossbeds; in upper part medium grained and interbedded with minor maroon shale	11.0	233.0
69	**Sandstone:** maroon and green; fine grained; laminated; interbedded with maroon siltstone and shale	1.0	222.0
68	**Sandstone:** light green; medium grained; massive; sharp lower and upper boundaries	1.0	221.0
67	**Sandstone:** medium green; medium grained; massive; interfingers laterally with shale conglomerate (3 cm maximum pebble diameter) and maroon shale; estimated 30% chert grains	10.0	220.0
66	**Sandstone:** conglomeratic; light grey; coarse grained; massive, tangential planar crossbeds; poorly sorted, angular	2.0	210.0
65	**Sandstone:** light green; medium grained; medium to thick bedded, tangential planar crossbeds; maroon shale partings	4.0	208.0
64	Covered: probably light grey and green, medium grained sandstone with zones of maroon shale	11.0	204.0
63	**Sandstone:** olive-green; medium grained; thin to medium bedded; interbedded with **conglomerate:** 1 cm maximum pebble diameter; medium to thin bedded; chert pebbles; unit poorly exposed	5.0	193.0
62	**Sandstone:** light green-grey; medium grained; medium to thick bedded; in upper part green, fine grained and thin bedded	6.5	188.0
61	**Conglomerate:** light grey to white; 1.5 cm maximum diameter; massive, vague large crossbeds; upper boundary gradational; matrix of medium grained sandstone; estimated 40% chert (Mineralogical analysis, GSC loc. C-45303, see Appendix 4)	4.0	181.5

Unit	Lithology	Thickness (m)	
		Unit	Total from base
60	**Sandstone:** light grey-green; medium grained; massive, planar and trough crossbeds; conglomeratic and coarse grained at base; sharp upper boundary	2.0	177.5
59	**Shale:** silty; maroon; upper contact sharp	4.5	175.5
58	**Sandstone:** olive-green; very fine grained; thin bedded; interbedded with green, silty, micaceous shale; (?)plant fragments	4.5	171.0
57	**Sandstone:** grey-green; medium grained; thick bedded to massive, tabular planar and trough crossbeds; thin bedded in upper part	4.5	166.5
56	**Sandstone:** conglomeratic; light yellow; coarse grained; very thick bedded; poorly sorted, angular	1.0	162.0
55	**Sandstone:** olive-green; very fine grained; thin bedded to laminated, ripple crossbeds; poorly exposed (Mineralogical analysis, GSC loc. C-45301, see Appendix 4)	5.0	161.0
54	**Sandstone:** green; fine grained; thin to medium bedded, interbedded with maroon, silty shale (Mineralogical analysis, GSC loc. C-45300, see Appendix 4)	3.0	156.0
53	**Sandstone:** lithic; orange; medium grained; medium to thick bedded; interbedded with coarse grained sandstone and discontinuous, maroon and green argillaceous siltstone; gradational upper contact; weathers maroon (Mineralogical analysis, GSC loc. C-45299, see Appendix 4)	9.0	153.0
52	**Sandstone:** quartzitic; light grey; medium to coarse grained; thick bedded to massive, planar and trough crossbeds; estimated 10% chert (Mineralogical analysis, GSC loc. C-45298, see Appendix 4)	6.0	144.0
	Series of small normal faults, displacement not known.		
51	**Sandstone:** conglomeratic; light brown-yellow; coarse to very coarse grained; thick to very thick bedded; estimated 30% chert	5.0	138.0
50	**Shale:** silty; maroon; very sharp upper contact	2.5	133.0
49	**Sandstone:** quartzitic, light grey; coarse grained; thick to medium bedded, planar tangential crossbeds; conglomerate (2 cm shale and 1 cm chert fragments) at base of beds, interbeds of medium grained and conglomeratic sandstone; rare (?)bone fragments	35.0	130.5
48	**Sandstone:** conglomeratic; light grey; medium to coarse grained; massive; grades upward to very fine grained sandstone and discontinuous shale	1.5	95.5
47	**Sandstone:** maroon and green; very fine grained; thin bedded; ripple marks; interbedded with maroon shale; sharp upper contact	0.5	94.0
46	**Sandstone:** conglomeratic; light grey; medium to coarse grained; massive, crossbedded	1.0	93.5
45	**Shale:** silty, maroon; very sharp upper contact	1.0	92.5
44	**Sandstone:** maroon; very fine grained; thin bedded; interbedded with maroon shale	0.5	91.5
43	**Sandstone:** light green-grey; coarse grained; thick bedded to massive, planar tangential crossbeds	2.5	91.0
42	**Sandstone:** green; medium grained; grading up into maroon, massive siltstone; sharp upper contact	2.5	88.5
41	**Shale:** silty, micaceous; maroon (Mineralogical analysis, GSC loc. C-45291, see Appendix 4)	2.0	86.0
40	**Sandstone:** maroon; very fine grained; thin bedded, interbedded with maroon shale and siltstone	1.5	84.0
39	**Sandstone:** light green-grey; medium grained; medium to thick bedded, sigmoidal and tabular planar crossbeds; partings and thin interbeds of maroon shale; shale conglomerate in lowest part; sharp lower boundary	3.5	82.5
38	**Shale:** silty, micaceous; maroon	1.0	79.0
37	**Sandstone:** maroon; very fine grained; very thin bedded to laminated; interbedded with maroon shale	1.0	78.0
36	**Sandstone:** grey-green; coarse grained; thick bedded, planar tabular crossbeds; interbeds of shale, shale conglomerate (4 cm maximum pebble diameter) at base	2.5	77.0
35	**Shale:** silty, micaceous; maroon	1.0	74.5
34	**Sandstone** (as Unit 36): very coarse grained and conglomeratic zones; reworked dolomite grains, estimated 10% chert and lithic grains	4.5	73.5
33	**Shale:** micaceous; maroon	1.5	69.0
32	**Sandstone:** calcareous; light green-grey and maroon; medium grained; thick bedded, planar and trough crossbeds, zones of contorted bedding; zones of shale conglomerate (pebble diameter <1 cm); calcite grains and cement, well rounded	7.0	67.5

Unit	Lithology	Thickness (m)	
		Unit	Total from base
31	**Shale:** very silty and micaceous; maroon, green in uppermost part	4.0	60.5
30	**Sandstone:** grey-green; fine to medium grained; thin bedded; grades upward into maroon, very fine grained sandstone	1.5	56.5
29	**Shale:** slightly calcareous, very silty and micaceous; maroon; massive; weathers rubbly; gradational upper contact	2.0	55.0
28	**Sandstone:** maroon; very fine grained; very thin bedded to laminated; interbedded with maroon shale; trace of calcareous grains and cement	0.5	53.0
27	**Sandstone:** light green-grey; medium grained; thin to very thin bedded; interbedded with maroon shale and siltstone	1.0	52.5
26	**Sandstone:** light green-grey; medium grained; massive, tangential-trough crossbeds; shale conglomerate (1 cm maximum pebble diameter) at base	3.5	51.5
25	**Sandstone:** light green-grey; medium grained; thin bedded; interbedded with maroon shale, zones of maroon shale pebbles	0.5	48.0
24	**Sandstone:** light green-grey; medium to coarse grained; massive, channel at base of unit; shale pebbles	1.0	47.5
23	**Sandstone:** quartzitic; light green-grey; fine grained; crossbedded; very thin bed of maroon shale; shale pebbles; estimated 40% chert and lithic fragments	1.0	46.5
22	**Sandstone:** slightly dolomitic; light green and maroon; medium grained; medium to thick bedded; desiccation cracks; very thin beds of maroon shale; estimated 20% chert and lithic fragments, dolomite as reworked grains	1.5	45.5
21	Covered: probably reddish shale	1.0	44.0
20	**Sandstone:** quartzite; light grey; medium grained; thick bedded to massive, slumping and distorted crossbeds; very thin zones of conglomerate; sharp upper contact	8.5	43.0
19	Covered: probably maroon shale and siltstone	6.0	34.5
18	**Sandstone:** medium green-grey; fine grained; medium to thin bedded; thin zones of shale conglomerate	1.95	28.5
17	**Limestone:** argillaceous; maroon; coarse calcilutite; thin bedded; probably resedimented; very sharp upper contact; interbedded with shale (Mineralogical analysis, GSC loc. C-45282, see Appendix 4)	3.40	26.55
16	**Siltstone:** calcareous; maroon; coarse grained; very thin bedded, planar crossbeds, small-scale (?)bioturbation; reworked calcite grains	0.65	23.15
15	**Sandstone:** calcareous; light green-grey; medium to coarse grained; thick bedded, crossbedded, lower surface channelled, mudcracks in upper part; shale conglomerate (1 cm maximum pebble diameter) at base; calcite as reworked grains and patchy cement	0.70	22.50
14	**Sandstone:** light green-grey; medium grained; thick bedded, tangential crossbeds in lower part; fine grained, calcareous, massive sandstone in upper part	1.75	21.80
13	**Limestone:** sandy-silty; maroon with grey-green zones; massive; (?)pedogenic	1.83	20.05
12	**Sandstone:** medium grey-green; medium grained; thick bedded, tabular and tangential crossbeds with shale flakes; thin bedded in upper part and interbedded with maroon shale	1.10	18.22
11	**Siltstone:** argillaceous; maroon; lense of green sandstone	0.82	17.12
10	**Sandstone:** dolomitic and calcareous; light grey; medium to coarse grained; thin bedded, planar tangential crossbeds; floating shale fragments	0.20	16.30
9	**Sandstone** (as Unit 10): thin bedded; zones of shale conglomerate	1.10	16.10
8	**Sandstone:** maroon; fine grained; very thin to thin bedded; interbedded with maroon shale; poorly sorted; sharp, erosional upper boundary	1.5	15.0
7	**Limestone:** as Unit 13	5.0	13.5
6	**Sandstone:** calcareous; light green-grey; very fine grained, medium grained at base; thin bedded; poorly sorted, resedimented calcite; shale conglomerate (maximum pebble diameter 0.4 cm) at base; gradational upper contact	0.5	8.5
5	**Limestone:** as Unit 13	1.0	8.0
4	**Sandstone** (as Unit 6): sharp lower boundary; in upper part interbedded with limestone of overlying unit	0.5	7.0
3	**Limestone:** as Unit 13	2.0	6.5
2	**Sandstone:** as Unit 6	0.5	4.5
1	**Limestone** (as Unit 13): lense of very fine grained sand at base.	4.0	4.0
	Underlying beds covered.		

SECTION B

This section is situated in the cliffs at the east side of Parker Bay (Field Station 55, Figure 11). The section was measured with an altimeter by Ulrich Mayr.

Emma Fiord Formation
(Lower Carboniferous)

Top of Unit 9 is formed by exposures near the highest point of the cliff. Conodonts of GSC locality C-99616 (late Viséan or early Namurian, Appendix 3) are from scree boulders just below the highest point on the cliff, stratigraphically less than 10 m above the of top Unit 9.

		Thickness (m)	
Unit	**Lithology**	**Unit**	**Total from base**
9	**Shale:** calcareous; dark grey; interbedded with **limestone:** argillaceous; dark grey; thin to medium bedded; lime mudstone; ostracodes	44.0	209.0
8	**Limestone** (as in Unit 1): interbedded with **limestone:** argillaceous and silty; dark grey; thick bedded; skeletal fragments	5.0	165.0
7	**Sandstone:** light grey; very fine grained; thick bedded with internal lamination, large trough crossbeds and channels; lithic arenite	6.0	160.0
6	**Limestone** (as above in Unit 8): lower contact very gradational	19.0	154.0
5	**Siltstone:** light green-grey; medium bedded; interbedded with very fine grained sandstone; lithic arenite	9.0	135.0
4	**Siltstone:** dark grey; thin bedded, planar and ripple crosslamination; lithic arenite	36.0	126.0
3	**Limestone:** argillaceous; dark grey; medium to thick bedded	16.0	90.0
2	**Limestone:** argillaceous and silty; medium bedded; lime mudstone; minor, very thin, shaly interbeds; bioturbation	39.0	74.0
1	**Siltstone** (as above in Unit 2): abundant thin shale interbeds.	35.0	35.0
	Described section is underlain by a 185 m thick interval of covered Emma Fiord Formation.		

SECTION C

This section is situated near Cape Hecla (Field Station 37). It was measured by R. Gardiner and D. Jones.

Emma Fiord Formation
(Lower Carboniferous)

End of outcrop

		Thickness (m)	
Unit	**Lithology**	**Unit**	**Total from base**
62	**Shale:** silty, calcareous; black; thin bedded, laminated, foliated; weathers black and orange-brown	4.5	646.5
61	**Siltstone:** black; thin bedded to massive with internal lamination, ripple marks, load casts; weathers dark brown	24.0	642.0
60	**Shale:** as in Unit 62	1.5	618.0
59	**Siltstone:** as in Unit 61	2.25	616.5
58	**Shale:** silty, calcareous; dark grey; very thin to thin bedded with interval lamination, foliated; weathers orange-brown	2.25	614.25
57	**Sandstone:** as in Unit 54; purple blotches	4.5	612.0
56	**Shale:** as in Unit 62	9.0	607.5
55	**Siltstone:** black; laminated to very thin bedded; weathers black to tan	1.5	598.5
54	**Sandstone:** very calcareous; light grey; fine grained; thin bedded; weathers tan	3.0	597.0
53	**Siltstone** (as below in Unit 52): grades upward into Unit 54	6.0	594.0
52	**Siltstone:** black; laminated; interbed of sandstone in lower part	18.0	588.0
51	**Siltstone** (as in Unit 98): laminated; grades into sandstone in upper part	6.5	570.0
50	**Siltstone:** as in Unit 40	13.0	563.5
49	**Sandstone** (as in Unit 41): small-scale crossbedding	3.0	550.5
48	**Siltstone:** dark grey; medium to thick bedded, small-scale crossbedding; weathers tan	4.5	547.5
47	**Sandstone:** calcareous; light grey; medium grained; medium to thick bedded; weathers orange-brown to orange	3.0	543.0
46	**Siltstone:** argillaceous; dark grey; thin bedded; oncolites; weathers orange-brown	3.0	540.0
45	**Sandstone:** dolomitic; light grey; very fine grained; laminated; skeletal fragments	6.0	537.0
44	**Siltstone:** calcareous; very thin bedded; shaly	6.0	531.0
43	**Sandstone:** as below in Unit 41	5.0	525.0
42	**Siltstone:** as below in Unit 40	9.25	520.0
41	**Sandstone:** calcareous; light grey; fine grained; laminated; scour marks, ripple marks; coarsens upward; weathers medium grey-brown	1.25	510.75
40	**Siltstone:** calcareous; black; thin bedded; shaly intervals; weathers black to tan	31.0	509.5
39	**Sandstone:** light grey; fine grained; massive; weathers grey	3.0	478.5
38	**Siltstone:** as below in Unit 32	30.0	475.5
37	**Siltstone** and **sandstone** (interbedded)		
	Siltstone: as below in Unit 33		
	Sandstone: slightly calcareous; light grey; fine grained; thick bedded	1.5	445.5
36	**Siltstone:** as below in Unit 32; interbedded with siltstone: sandy, calcareous; light grey; thin bedded to massive, cross-bedded	48.0	444.0

		Thickness (m)	
Unit	Lithology	Unit	Total from base
35	**Siltstone**: calcareous; light and medium grey; massive with some thin beds; sandy in upper part	3.0	396.0
34	**Siltstone:** very calcareous: black; very thin bedded; horizontal burrows; weathers dark grey; skeletal fragments	9.0	393.0
33	**Siltstone**: calcareous; light grey; medium bedded; coarsening-upward sequence; weathers grey	7.5	384.0
32	**Siltstone:** shaly, calcareous; black; laminated to thin bedded; weathers black	1.5	376.5
31	**Sandstone:** quartzitic; light grey; fine grained; medium bedded; weathers various shades of grey	34.5	375.0
30	**Siltstone:** sandy; medium grey; medium bedded; bioturbated; grades upward into dark grey, finer grained siltstone	7.5	340.5
29	**Sandstone:** as below in Unit 23	1.5	333.0
28	**Sandstone:** calcareous, conglomeratic; light grey; fine to medium grained; medium bedded; siltstone and shale clasts; interbeds of shaly siltstone	21.75	331.5
27	**Sandstone:** as below in Unit 23	0.75	309.75
26	**Siltstone:** as below in Unit 20	1.5	309.0
25	**Sandstone:** as below in Unit 23; load casts	1.5	307.5
24	**Siltstone:** as below in Unit 20	3.0	306.0
23	**Sandstone:** very calcareous; light grey; fine grained; thick bedded; rock fragments; weathers light grey-green	1.5	303.0
22	**Siltstone:** sandy; black; thin to thick bedded with interval lamination, scour marks, ripple marks; interbeds of **sandstone:** calcareous; fine grained; interlaminated with fine calcarenite; abundant ostracodes	63.0	301.5
21	**Oolite** with interbeds of fine grained sandstone	1.5	238.5
20	**Siltstone:** sandy; black; laminated, bioturbation	21.0	237.0
19	**Sandstone:** quartzitic; light grey; fine grained; thick bedded; weathers grey-green to grey-brown	12.0	216.5
18	**Siltstone:** sandy; black; thick to very thick bedded; unit poorly exposed	34.0	204.0
17	**Sandstone:** quartzitic; light grey; medium grained; massive; about 50% chert grains; weathers medium grey	2.0	170.0
16	**Siltstone:** calcareous, dolomitic, sandy; dark grey; very thin to medium bedded; shaly intervals, pyrite; weathers dark grey; ostracode fragments (Mineralogical analysis, GSC loc. C-70155, see Appendix 4)	21.0	168.0
15	**Dolomite:** silty; light grey; very fine crystalline; medium bedded; desiccation cracks and mudclasts; weathers light grey-brown	1.5	147.0
14	**Siltstone:** shaly, calcareous; black; laminated to thin bedded; trace fossils on bedding planes	10.5	145.5
13	**Sandstone:** calcareous; light grey; medium grained; thick bedded; fine grained in upper part	6.0	135.0
12	**Limestone:** very sandy; light grey; laminated; interbedded with **siltstone:** very calcareous; black	18.0	129.0
11	**Siltstone:** sandy, very calcareous; dark grey to black; thick bedded to massive; weathers dark grey	7.0	111.0
10	**Limestone:** very sandy; light grey; laminated; scour marks; pelletoidal-skeletal packstone; weathers light brown; crinoid fragments	0.5	104.0
9	**Siltstone:** sandy, very calcareous; black; massive; small trough crossbeds; foliated	4.5	103.5
8	**Limestone:** silty; medium grey-brown; thin bedded with some medium beds; weathers dark grey	4.5	99.0
7	**Siltstone:** light grey; thin to medium bedded; black shale at base of unit; weathers grey-brown	12.0	94.5
6	**Sandstone:** conglomeratic, coarse grained; grading upward into fine grained sandstone, siltstone, and grey-green shale (Mineralogical analysis, GSC loc. C-70148, see Appendix 4)	3.0	82.5
5	**Siltstone:** very calcareous and dolomitic; light to medium grey; thick bedded to massive with interval lamination; burrows; shaly intervals	64.5	79.5
4	**Limestone:** argillaceous; black; very thin to thin bedded; interbedded with light grey limestone	6.75	15.0
3	**Sandstone:** quartzitic; interbedded with grey shale	1.5	8.25
2	**Limestone:** silty, argillaceous; black; very thin to thin bedded; skeletal packstone; ostracodes	2.25	6.75
1	**Sandstone:** medium grey, fine grained; medium bedded with internal lamination (Mineralogical analysis, GSC loc. C-70142, see Appendix 4).	4.5	4.5

Underlying beds not exposed.

Unit	Lithology	Thickness (m)	
		Unit	Total from base

SECTION D

This section is situated on the southeast side of a large nunatak on the northwest side of the upper part of Henrietta Nesmith Glacier (Field Stations 18 and 19, Figure 20). The section was measured and described by Ulrich Mayr and D. Jones.

The Assistance Formation is overlain with sharp contact by pink sandstone assigned to the Trold Fiord Formation. In a nunatak about 6 km southwest of Section D (Field Station 49) the complete Trold Fiord Formation is present and is 475 m thick (C. Henderson, pers. comm., 1979).

Assistance Formation (Permian)

Unit	Lithology	Thickness (m) Unit	Thickness (m) Total from base
39	**Siltstone:** calcareous; dark grey; thin bedded; interbedded with **sandstone:** light yellow; fine grained in upper part; abundant *Zoophycos* sp. and brachiopods (GSC loc. C-69897, 9 m above base of unit, see Appendix 3b)	61.5	832.8
38	(Felsenmeer with small isolated outcrops) At 726.3 m brachiopods (GSC loc. C-82539, Early Permian, Roadian, see Appendix 3b); at 711.3 m **sandstone:** very siliceous; dark grey; very fine grained; thin bedded; sublitharenite in scree; abundant *Zoophycos* sp., and brachiopods (Mineralogical analysis, GSC loc. C-69898, see Appendix 4); at 661.8 m **siltstone:** light grey; thin bedded; *Zoophycos* sp.; at 635 m **sandstone:** very hard, very slightly calcareous; medium grey; very fine grained; thin bedded, vertical burrows; *Zoophycos* sp. (Mineralogical analysis, GSC loc. C-69896, see Appendix 4)	136.5	771.3
37	Covered.	13.5	634.8
	Complete thickness of Assistance Formation 211.5 m		

Sabine Bay Formation
(Permian)

Contact sharp, disconformable

Unit	Lithology	Thickness (m) Unit	Thickness (m) Total from base
36	Felsenmeer, consisting of **sandstone:** very slightly calcareous; light grey; fine grained; (?)thick bedded, crossbeds; *Scolithos*; at top of unit **sandstone:** quartzitic; light yellow; medium grained; medium to thick bedded	28.5	621.3

Belcher Channel Formation
(Upper Carboniferous and Permian)

Contact sharp, disconformable

Unit	Lithology	Thickness (m) Unit	Thickness (m) Total from base
35	**Sandstone:** calcareous; medium grey; very fine grained; thick bedded; vertical burrows; lenses of brachiopod, bryozoan and other fossil fragments, *Zoophycos* sp. abundant, particularly at top (GSC loc. C-69894, Early Permian, Artinskian, see Appendix 3b)	12.5	592.8
34	**Limestone:** slightly argillaceous; dark grey; medium bedded; lime mudstone; abundant large brachiopods and *Zoophycos* sp.	2.5	580.3
33	**Limestone:** siliceous and silty, fetid; grades upward into calcareous, very fine grained sandstone with *Zoophycos* sp.	4.5	577.8
32	**Sandstone:** calcareous; medium grey; beds with very abundant brachiopods	4.0	573.3
31	**Sandstone:** calcareous; medium grey; very fine grained; thin bedded, tangential planar crossbeds	0.5	569.3
30	**Limestone:** dark grey; fine grained; thick bedded to massive; zones of black chert nodules; skeletal grainstone; in upper part siliceous and with very abundant brachiopods	2.5	568.8
29	**Limestone:** medium grey; medium grained; massive; large black or white chert nodules; skeletal grainstone; interbeds of darker skeletal packstone; abundant echinoid and platy (algal?) fragments	78.0	546.3
28	**Limestone:** dark grey; massive; skeletal wackestone	3.0	468.3
27	**Limestone:** sandy, siliceous; light grey; medium grained; massive; skeletal grainstone; white chert nodules and zones of coarse grained skeletal grainstone; abundant brachiopods	19.5	465.3
26	**Limestone:** medium grey; fine to medium grained; thin to medium bedded; skeletal packstone interbedded with grainstone: light grey; medium to coarse grained; thin to very thin bedded; chert beds in upper part; abundant brachiopods, locally forming coquina	18.0	445.8
25	**Limestone:** light grey; fine grained; massive; skeletal grainstone; brachiopods common	12.7	427.8
24	**Limestone:** siliceous, sandy; medium grey fine calcarenite; medium bedded; skeletal grainstone, locally gradational to skeletal packstone; interbedded with light grey chert; fusulinids at 389.5 m (GSC loc. C-69885, Early Permian, early Artinskian, see Appendix 3b)	26.0	415.1
23	**Limestone:** siliceous; medium to thick bedded; skeletal packstone to wackestone; chert nodules, in upper 10 m very abundant chert nodules and beds; *Zoophycos* sp., productid brachiopods, fusulinids at 350.1 m (GSC loc. C-69884, early Permian, Sakmarian, see Appendix 3b)	45.0	389.1

Unit	Lithology	Thickness (m)	
		Unit	Total from base
22	Covered: at 317.1 m small outcrop of limestone as below; chert nodules; abundant corals, fusulinids (GSC loc. C-69883, Early Permian, Sakmarian, see Appendix 3b)	42.0	344.1
21	**Limestone:** siliceous and silty; medium grey; thin bedded; lime sandstone gradational to calcareous siltstone; *Zoophycos* sp., fine, scattered fossil debris, small corals, fusulinids	15.0	302.1
20	Covered: probably limestone as below; large gastropod in scree	43.5	287.1
19	**Limestone:** very silty, argillaceous; very dark grey; thin bedded; skeletal wackestone, shaly intervals; corals, (GSC loc. C-69881 at 224 m, Early Permian, see Appendix 3b); brachiopods, calcispheres, *Zoophycos* sp. fusulinids (GSC loc. C-69882 at 228.6 m, Early Permian, Sakmarian, see Appendix 3b)	20.1	243.6
18	**Siltstone:** grading to very fine sandstone, calcareous, hard; thin bedded, laminated; subarkose; corals	14.5	223.5
17	**Limestone:** silty and argillaceous; thin bedded; thin zones of skeletal debris, *Zoophycos* sp.	34.5	209.0
16	Covered: probably as Unit 14 below; *Zoophycos* sp. in scree	9.0	174.5
15	**Limestone:** light grey; medium to coarse grained; massive; skeletal grainstone	2.5	165.5
14	**Limestone:** very argillaceous and silty; dark grey; thin bedded; *Zoophycos* sp., trace fossils, lenses with abundant fusulinids at top of unit (GSC loc. C-69878, Early Permian, early Sakmarian, see Appendix 3b)	11.0	163.0
13	**Limestone:** light grey; medium to coarse grained; very thick bedded; skeletal grainstone; interbedded with fine grained skeletal packstone, chert nodules	20.6	152.0
12	**Limestone:** very argillaceous, bituminous; very dark grey; thin bedded; lime mudstone gradational to dolomitic, silty shale; *Zoophycos* sp., brachiopods, corals, fusulinids at 110.7 m (GSC loc. C-69877, Early Permian, early Sakmarian, see Appendix 3b)	29.5	131.4
11	Interval mostly covered: isolated outcrops of **limestone:** silty and argillaceous; medium grey-green; thin bedded; lime mudstone; shaly interbeds; chert nodules in upper part; crinoids, echinoids, syringoporid and other corals, fusulinids at 87.2 m (GSC loc. C-69875, Early Permian, late Asselian, see Appendix 3b)	18.5	101.9
10	**Limestone:** light grey; skeletal grainstone, medium to coarse grained; thick bedded	2.1	83.4
9	**Limestone:** argillaceous; medium green-grey; medium bedded; lime mudstone and skeletal wackestone; partly silicified corals and bryozoans, fusulinids, at 78.4 m (GSC loc. C-69874, Early Permian, Asselian, see Appendix 3b)	7.9	81.3
8	**Siltstone:** argillaceous and calcareous; medium green-grey; thin to very thin bedded; gradational upper contact	0.9	73.4
7	**Limestone:** bituminous; dark grey; massive; skeletal packstone; gastropods, corals; unit covered in upper part	11.8	72.5
6	**Limestone:** medium dark grey; massive; lime mudstone, grades laterally into siliceous oolite	1.7	60.7
5	**Limestone:** light grey; medium grained; thick bedded to massive; corals, phylloid algae	1.5	59.0
4	**Limestone:** siliceous and silty; medium grey; lime mudstone; chert nodules	5.9	57.5
3	**Limestone:** medium grey; skeletal packstone, medium to fine grained; medium to thick bedded; large chert nodules in upper part	11.8	51.6
2	**Limestone:** siliceous, dark grey; thick bedded; chert nodules; corals, fusulinids (GSC loc. C-69868, Early Permian, Asselian, see Appendix 3b)	1.5	39.8
1	**Limestone:** sandy; medium grey; thick bedded; skeletal packstone; syringoporid corals, phylloid algae, fusulinids at 17.7 m (GSC loc. C-69867, Early Permian, Asselian, see Appendix 3b).	38.3	38.3
	Underlying beds not exposed.		

SECTION E1

This section is situated in the cliffs at the west side of a steep mountain [Field Station 50 (Fig. 26) to Field Station 14 (Fig. 39)] at the lower part of de Vries Glacier. The section was measured and described by Ulrich Mayr and J. Pulishy.

(?)Degerböls Formation
(Permian)

19	**Limestone:** light grey; mostly thick bedded; skeletal grainstone, crinoidal calcirudite; thin interbeds of chert; brachiopods common (GSC loc. C-45469; Permian, late Leonardian to early Wordian; from lower part of unit, Permian; see Appendix 3); lower contact very sharp; unit mostly inaccessible, thickness estimated.	230.0	991.1

Unit	Lithology	Thickness (m)	
		Unit	Total from base
	Assistance Formation (Permian)		
18	**Limestone:** sandy; dark grey; thick bedded; interbedded with chert, spiculite; abundant bryozoans and small brachiopods on bedding planes; unit shaly in lower part (GSC loc. C-45466 from middle part of unit; Permian, late Leonardian to early Wordian; see Appendix 3), unit mostly snow covered, thickness estimated.	80.0	761.1
	Nansen Formation **(Upper member)** (Upper Carboniferous and Permian)		
	Contact not examined		
17	Inaccessible: probably similar to dolomite below in Unit 16; thickness estimated	150.0	681.1
16	**Dolomite:** sandy; light grey; fine to very fine crystalline; very thick bedded with zones of lamination and internal thin bedding, resistant unit; stromatolitic	30.0	531.1
15	**Dolomite:** sandy; light grey; medium and fine crystalline; massive with internal lamination; poorly exposed in upper part	256.5	501.1
14	**Dolomite:** silty, siliceous; medium to dark grey; fine crystalline; fenestral lamination; platy weathering	12.0	244.6
13	**Dolomite:** light grey; fine to very fine crystalline; massive; phylloid algae; interbedded with dolomite, dark grey, very fine crystalline; algal lamination	34.5	232.6
12	**Dolomite:** light grey; fine crystalline; massive, burrowed	49.5	198.1
11	**Dolomite:** light grey; very fine to aphanocrystalline; massive; very light grey mottling, burrowed	27.0	148.6
10	**Dolomite:** light grey; fine to very fine crystalline; thick bedded with interval lamination; silicified zones	4.5	121.6
9	**Dolomite:** light grey; fine crystalline; massive; (?)skeletal fragments	21.5	117.1
8	**Dolomite:** silty, calcareous, siliceous; very light grey; fine crystalline; massive; skeletal fragment, *Syringopora* type corals; rare interbeds of chert nodules and skeletal grainstone	44.8	95.6
7	Unit inaccessible: medium bedded, (?)dolomite	17.0	50.8
6	Covered: probably dolomite as below with interbeds of dark green, dolomitic shale	2.0	33.8
5	**Dolomite:** light grey; medium crystalline; medium bedded; sucrosic; weathers slightly recessive	6.0	31.8
4	**Dolomite:** light grey-orange; very hard, vuggy, medium crystalline; massive; unit varies in thickness along strike	12.5	25.8
3	**Dolomite:** medium to light grey; very hard, medium crystalline; very thick bedded; dissolved (?)foraminifers	5.8	13.3
2	**Dolomite:** calcareous; medium grey; fine crystalline; medium bedded; recrystallized fusulinids	3.0	7.5
1	**Limestone:** dark grey; massive; skeletal wackestone.	4.5	4.5
	Underlying beds not exposed.		

SECTION E2

This section is situated in the cliffs on the southwest side of the lower part of de Vries Glacier (Field Station 40). The section was measured, in part with an altimeter, and described by Ulrich Mayr and D. Jones.

Section overlain by an estimated 600 m of inaccessible, massive carbonates.

	Nansen Formation **(Upper member)** (Upper Carboniferous and Permian)		
12	**Dolomite:** calcareous; light grey; fine crystalline; massive; bird's-eye texture and traces of brecciation, (?)algal components; very resistant	20.0	333.0
11	**Dolomite:** sandy; light grey; medium crystalline; massive; coarse skeletal grainstone with foraminifers, codiaceans and other coralline algal fragments	12.0	313.0
10	**Limestone:** silty and dolomitic; very dark grey; massive; interlaminated with calcareous siltstone	6.0	301.0
9	**Dolomite:** siliceous; dark grey; very fine crystalline; medium bedded; rare crinoid fragments, sponge spicules and other siliceous organic remains; very sharp lower boundary.	2.0	295.0
	Nansen Formation **(Middle member)** (Upper Carboniferous)		
8	**Siltstone:** shaly; dark grey; laminated lenses of medium bedded sandstone; papery weathering, poorly exposed, recessive unit	51.0	293.0
7	**Sandstone:** micaceous; medium grey; fine grained; thin to medium bedded; in middle part of unit abundant shale partings and shale interbeds	8.0	242.0
6	**Shale:** micaceous and silty; dark grey; papery weathering	9.0	234.0

		Thickness (m)	
Unit	Lithology	Unit	Total from base
5	**Sandstone:** light grey; mostly medium grained; very thick bedded, vague channels; shale clasts throughout; interbeds of black shale; sandstone poorly sorted, angular clasts; very sharp lower boundary	72.0	225.0
4	**Dolomite:** medium grey; fine crystalline; massive; scattered crinoid fragments	15.0	153.0
3	**Dolomite:** dark grey; fine crystalline; massive; very uniform lithology. (Units 3 and 4 are on the lower flank of a small reef.)	15.0	138.0
2	**Anhydrite:** as below; minor interbeds of dark dolomite	31.0	123.0
1	**Dolomite:** very dark grey; very fine crystalline to aphanocrystalline; massive; rare skeletal fragments; interbedded with anhydrite; massive with slight internal modular lamination.	92.0	92.0

Underlying beds not exposed.

SECTION E3

This section is situated in the cliffs at the head of Yelverton Inlet (Field Stations 8 and 11, Figure 23). The section was measured by Ulrich Mayr and J. Calvert.

Top of mountain

Nansen Formation
(Lower member)
(Upper Carboniferous)

		Thickness (m)	
Unit	Lithology	Unit	Total from base
216	**Dolomite:** calcareous in uppermost part; medium dark grey; medium crystalline; thin to medium bedded, individual beds laminated; abundant chert; relict fabric coarse grained skeletal grainstone; vertical, laminar differentiation of grain size, poorly exposed; abundant crinoids, bryozoans, stromatoporoids and corals	4.5	1365.5
215	Inaccessible, snowfield (estimated)	12.0	1361.0
214	**Dolomite:** medium dark grey; medium crystalline; medium bedded; bedded black chert in uppermost part; abundant skeletal fragments, crinoids up to 1 cm in diameter; solitary corals, zones of stromatolites	10.5	1349.0
213	**Dolomite:** dark and very dark grey; medium crystalline; thick bedded and massive; chert nodules; comminuted fossil fragments on bedding planes; alternating resistant and recessive intervals; abundant syringoporid and other colonial corals, gastropods	90.0	1338.5
212	Covered	6.0	1248.5
211	**Dolomite:** dark and very dark grey; medium crystalline, locally grading into fine crystalline; thin bedded with isolated thick beds, lamination of some individual beds, fracturing and brecciation in upper part of unit; vague pelletoid(?) outlines, possible pelletoidal grainstone originally; large (0.8 m) syringoporid coral in lower part	16.5	1242.5
210	**Dolomite:** very dark and medium grey; medium to fine crystalline; medium and thick interbedded, minor brecciation; chert nodules; crinoidal fragments on bedding planes, brachiopods	8.5	1226.0
209	**Dolomite:** very dark and medium grey; massive, with discontinuous bedding planes; fractured, vuggy	3.5	1217.5
208	**Dolomite:** very dark grey, fine crystalline; thin bedded; rare chert nodules	2.5	1214.0
207	**Dolomite:** dark grey; medium crystalline; massive; chert nodules; texture of thin and very thin bedded lime mudstone and fine grained pelletoidal-skeletal packstone, minor brecciation, large dolomite-lined vugs	9.0	1211.5
206	**Dolomite:** very dark grey; medium crystalline; massive in lower part, thin bedded at top; at base texture of very fine grained pelletoidal packstone, in upper part fine grained skeletal packstone	3.5	1202.5
205	Covered	1.5	1199.0
204	**Dolomite:** medium grey; medium crystalline; thin and medium interbedded; unit poorly exposed	14.5	1197.5
203	Covered	3.5	1183.0
202	**Dolomite:** medium grey; coarse crystalline; thick bedded	2.0	1179.5
201	**Dolomite:** medium grey; medium crystalline; thin bedded	1.5	1177.5
200	**Dolomite:** medium grey; medium crystalline; medium to thick bedded	2.0	1176.0
199	**Dolomite:** very dark grey; medium crystalline; thin bedded, nodular	0.5	1174.0
198	**Dolomite:** dark grey and medium grey interbedded; medium and fine crystalline; thin and thick bedded	14.5	1173.5
197	Covered: probably coarse crystalline dolomite	11.0	1159.0
196	**Dolomite:** dark grey, medium crystalline; massive with faint traces of thin bedding	4.0	1148.0
195	**Dolomite:** dark grey; coarse crystalline; thin bedded	5.0	1144.0

Unit	Lithology	Thickness (m)	
		Unit	Total from base
194	**Dolomite:** light grey; coarse to very coarse crystalline; massive	1.0	1139.0
193	**Limestone:** slightly argillaceous; black; thin bedded with irregular, nodular bedding planes; partings of calcareous shale; lime mudstone with scattered skeletal fragments and very rare calcispheres and silt grains; rare corals, abundant brachiopods in shale beds	6.5	1138.0
192	Covered	5.0	1131.5
191	**Dolomite:** very dark grey; medium crystalline; massive; in uppermost part medium grey and coarse crystalline	1.0	1126.5
190	**Dolomite:** black; medium crystalline; thin bedded	1.0	1125.5
189	**Dolomite:** black; coarse crystalline; massive; upper contact gradational	1.0	1124.5
188	**Limestone:** medium to dark grey; thin to medium interbedded, nodular bedding planes; patches of black, medium crystalline dolomite; lime mudstone with skeletal fragments; brachiopods common	6.5	1123.5
187	**Shale:** calcareous; maroon; sharp upper boundary	1.0	1117.0
186	**Limestone:** yellow-brown with maroon mottles; thin to medium bedded; lime mudstone to medium grained skeletal wackestone; gastropods, ostracodes, calcareous algae, fusulinids (GSC loc. C-45421, Upper Carboniferous, Bashkirian, see Appendix 3b)	1.0	1116.0
185	Covered: maroon shale and maroon, very fine grained sandstone	1.0	1115.0
184	**Dolomite:** medium grey; medium crystalline; thick bedded	2.0	1114.0
183	**Limestone:** medium grey; thin bedded flaser bedding; interbedded with minor light green shale; lime mudstone with skeletal fragments; brachiopods common	1.2	1112.0
182	**Dolomite:** dark grey; coarse crystalline; thin bedded, nodular	0.8	1110.8
181	**Limestone** (as above in Unit 183): interbedded with abundant light green shale; brachiopods common	1.0	1110.0
180	**Dolomite:** dark grey; coarse and medium crystalline; massive with interbedded thin bedded; lenticular shaped vugs in massive units	5.0	1109.0
179	**Dolomite:** medium grey-green; medium crystalline; massive, with nodular thin beds; slightly vuggy; uppermost 0.3 m **limestone:** medium grey; thin bedded, nodular; medium grained skeletal wackestone	12.5	1104.0
178	**Dolomite:** black; medium crystalline; thin bedded, nodular, medium bedding in uppermost part; lime mudstone texture; abundant skeletal fragments in uppermost part	4.0	1091.5
177	Covered	4.0	1087.5
176	**Dolomite:** medium grey; medium crystalline; thin bedded, with medium and thick beds in upper part; bird's-eye texture	1.5	1083.5
175	Covered: probably mostly dolomite; trace of red shale at base of unit	5.2	1082.0
174	**Dolomite:** medium grey; medium crystalline; thick bedded; vuggy; weathers yellow	0.3	1076.8
173	**Sandstone:** dolomitic; very light grey; coarse grained; thick bedded; planar, tabular crossbeds (0.4 m); conglomeratic zones with pebbles (6 cm) of green, siliceous sandstone	2.0	1076.5
172	**Dolomite:** medium grey; coarse crystalline; thin bedded with medium to thick beds in upper part	3.0	1074.5
171	**Sandstone:** very light brown; medium grained; thick bedded; conglomeratic zones; grading upward into **dolomite:** light grey; medium crystalline; conglomeratic and sandy	0.5	1071.5
170	**Sandstone** (as above in Unit 171): conglomeratic zones with 1.5 cm pebbles; planar, tangential crossbeds	1.5	1071.0
169	**Dolomite:** as above in Unit 172	1.5	1069.5
168	**Dolomite:** medium grey; coarse crystalline; massive	4.5	1068.0
167	**Dolomite:** medium grey; medium to coarse crystalline; thin bedded, with medium to thick beds in upper part; texture of fine grained pelletoidal grainstone	3.0	1063.5
166	**Sandstone:** quartzitic; light maroon; medium grained; bedding varies from massive to very thin, zones with very regular lamination, planar and trough crossbedding; 0.3 m of maroon shale in uppermost part; well sorted and rounded, chert and quartz grains, some conglomeratic zones; sharp upper contact	9.5	1060.5
165	**Dolomite:** medium grey; medium crystalline; massive; bird's-eye lamination; sharp upper contact	2.0	1051.0
164	**Sandstone:** light maroon; medium grained; thick bedded and tangential planar crossbeds in lower part; in upper part fine to very fine grained; dark maroon; thin bedded; unit poorly exposed	3.0	1049.0

Unit	Lithology	Thickness (m)	
		Unit	Total from base
163	**Dolomite:** medium grey; medium crystalline; thin bedded; maroon shale on uppermost bedding plane; weathers yellow, unit poorly exposed	1.5	1046.0
162	Covered: probably maroon, sandy shale	1.5	1044.5
161	**Dolomite:** medium grey; medium crystalline; thin bedded; vuggy	4.5	1043.0
160	**Dolomite:** coarse crystalline; medium grey; massive; very slightly silty; medium grained pelletoidal grainstone	1.5	1038.5
159	**Dolomite:** medium grey; medium crystalline; thin bedded; vuggy	4.5	1037.0
158	**Dolomite:** medium grey; medium crystalline; massive with nodular thin beds; bird's-eye structure; texture of clotted lime mudstone	1.5	1032.5
157	**Sandstone:** light maroon; very fine grained; thin to medium bedded, lamination; sharp upper boundary	0.5	1031.0
156	Covered: probably maroon, fine grained, thick bedded sandstone	4.0	1030.5
155	**Dolomite:** medium grey; medium crystalline; massive; bird's-eye structure	1.5	1026.5
154	**Dolomite:** increasingly sandy upward, medium grey; coarse crystalline; thin and thick interbedded; texture of lime mudstone	4.5	1025.0
153	**Sandstone:** maroon; coarse grained; thick bedded; slightly conglomeratic, poorly sorted; unit poorly exposed	6.5	1020.5
152	**Breccia:** red-brown; massive; 0.4 m slabs of maroon, medium grained sandstone with conglomerate matrix; slump breccia(?)	1.5	1014.0
151	**Dolomite:** medium grey; medium to coarse crystalline; massive	5.5	1012.5
150	**Conglomerate:** green-grey; massive, laminated with very coarse grained sandstone, planar tabular crossbeds; 3 cm pebbles of maroon sandstone, white chert and green chert, grades upward into green, fine grained quartzitic sandstone; sharp upper contact	2.5	1007.0
149	**Conglomerate** and **sandstone:** as above in Unit 150	2.0	1004.5
148	**Sandstone:** green-grey; medium grained; thick bedded; floating very coarse grains; weathers maroon; in upper part of unit, medium bedded, maroon, fine grained sandstone	5.0	1002.5
147	**Sandstone:** medium grey; fine grained; thick bedded; cherty zones and nodules; weathers maroon	2.5	997.5
146	**Siltstone:** calcareous; brown-green; thin bedded, nodular; abundant large corals	2.5	995.0
145	Covered: probably bedded limestone, medium grey, thin green shale partings; lime mudstone and skeletal wackestone; abundant bryozoans, crinoids, corals and brachiopods in scree	10.5	992.5
144	**Limestone:** argillaceous; black; laminated to very thin bedded; resedimented coarse to medium calcilutite; rare brachiopods	9.0	982.0
143	**Dolomite:** medium grey; coarse crystalline; thin bedded; weathers green-yellow	3.5	973.0
142	**Dolomite:** dark grey; coarse crystalline; thin bedded; weathers dark grey to black	2.0	969.5
141	**Sandstone:** grades from light maroon at base to very light grey at top; medium grained; medium to thick bedded, lamination in individual beds; lower part impure, upper part well sorted and rounded, zones with floating black chert pebbles; weathers brown	4.0	967.5
140	**Sandstone:** maroon; fine grained; thick bedded, slumped crossbeds in uppermost part; laminae of coarse crystalline dolomite	3.0	963.5
139	Covered: probably similar to Unit 140	3.0	960.5
138	**Dolomite:** dark grey; coarse crystalline; very uniformly thin bedded; very resistant, weathers light brown-maroon	8.0	957.5
137	**Dolomite:** sandy and silty; dark grey to black; medium crystalline; thick bedded, nodular; texture of lime mudstone with (?)bioturbation; in lower part of unit interbeds of sandstone, shale and limestone; sharp upper boundary	2.0	949.5
136	**Sandstone:** calcareous and dolomitic; medium green-grey; medium grained; medium to thick bedded, individual beds laminated, thin nodular zones; skeletal grainstone in uppermost part; weathers rusty brown	2.5	947.5
135	**Sandstone:** light green-grey and maroon; medium grained; medium bedded with lamination, very thick bed at base, upper contact channelled; well sorted; weathers dark yellow	2.5	945.0
134	Covered	3.5	942.5
133	**Sandstone:** maroon; coarse grained; thick bedded, tabular planar crossbedding; conglomeratic zone (2 cm maximum pebble diameter) and very coarse grained sandstone at base	1.5	939.0
132	Covered	1.5	937.5
131	**Sandstone:** maroon; very fine grained; thin to very thin bedded	2.0	936.0
130	Covered: probably maroon sandstone	3.5	934.0

Unit	Lithology	Thickness (m)	
		Unit	Total from base
129	**Sandstone:** maroon; fine grained; thin to medium bedded, sigmoidal and tabular planar crossbeds; zones of conglomerate and coarse grained sandstone (4 cm maximum pebble diameter)	9.0	930.5
128	**Sandstone:** maroon; fine and medium grained; thin to medium bedded; unit poorly exposed	4.5	921.5
127	**Dolomite:** calcareous and slightly silty; light grey; coarse crystalline; thin bedded, nodular; ghosts of skeletal fragments; poorly preserved large brachiopods common	1.5	917.0
126	**Shale:** dark grey; papery; interbedded with dark green, medium grey sandstone	2.5	915.5
125	Covered: probably like Unit 123	2.0	913.0
124	**Limestone:** argillaceous and silty; black; thin bedded, nodular; interbedded with black, medium bedded dolomite; texture of poorly sorted, coarse grained skeletal grainstone; abundant brachiopods, echinoderm fragments, gastropods, calcareous algae (GSC loc. C-45383, Upper Carboniferous, Bashkirian, see Appendix 3b)	4.0	911.0
123	**Shale:** calcareous; black; thin bedded; nodular; brachiopods	2.5	907.0
122	**Siltstone:** calcareous; black; thin bedded; abundant skeletal fragments.	2.0	904.5

Borup Fiord Formation
(Upper Carboniferous)

Contact conformable, gradational

Unit	Lithology	Thickness (m)	
		Unit	Total from base
121	**Sandstone:** dolomitic; white; medium grained; thin to medium bedded; well sorted, subrounded to rounded; in uppermost part of unit interbedded with very thin black chert and green shale partings	2.5	902.5
120	**Sandstone:** maroon; medium and coarse grained; interbeds of shale	14.5	900.0
119	**Sandstone:** maroon; fine grained; thin to thick bedded; shale partings	4.5	885.5
118	**Shale:** maroon	1.0	881.0
117	Covered	5.5	880.0
116	**Sandstone:** maroon; coarse grained; conglomeratic, slightly quartzitic, well sorted	3.0	874.5
115	Covered: probably maroon sandstone	33.0	871.5
114	**Sandstone:** maroon; upward fining from coarse grained to fine grained; medium to thick bedded; interbeds of siltstone; dolomitic in uppermost part	19.5	838.5
113	Covered	4.5	819.0
112	**Sandstone:** maroon; medium to coarse grained; thick bedded	16.5	814.5
111	Covered	6.0	798.0
110	**Conglomerate:** maroon; 11 cm maximum pebble diameter, fining upward to coarse grained sandstone; crossbedding in sandstone; pebbles of green and red chert and coarse grained sandstone	9.0	792.0
109	**Sandstone:** dolomitic, micaceous; maroon; fine grained, with very fine grained laminae; thick bedded to massive, rare crossbeds; interbeds of siltstone; subangular to subrounded, well sorted	22.5	783.0
108	**Shale:** maroon with green specks; zones of dolomite concretions	13.5	760.5
107	**Sandstone:** maroon; medium grained; thick bedded, crossbedded	1.5	747.0
106	**Conglomerate:** maroon; fining upward from base (18 cm maximum pebble diameter); red and green chert pebbles, coarse grained matrix	6.5	745.5
105	**Conglomerate:** maroon; 5 cm maximum pebble diameter; thick bedded; interbedded with very coarse grained, conglomeratic, crossbedded, medium bedded sandstone; siltstone pebbles; upper boundary of conglomerate beds to sandstone gradational, lower boundary of conglomerate beds to sandstone sharp	4.0	739.0
104	**Sandstone:** maroon; fine grained; massive	4.5	735.0
103	**Sandstone:** grey-maroon; very coarse grained; massive; conglomeratic with green and brown chert pebbles, 5 cm maximum pebble diameter	4.5	730.5
102	**Sandstone:** micaceous; maroon; fine grained; medium to thick bedded, lamination of individual beds, very uniform; siltstone interbeds at base (Mineralogical analysis, GSC loc. C-45375, see Appendix 4)	31.5	726.0
101	**Conglomerate:** maroon; 13 cm maximum pebble diameter; massive; pebbles of green and white chert and maroon sandstone	12.0	694.5
100	Inaccessible: regularly interbedded maroon siltstone and conglomeratic sandstone; alternating units 3 to 5 m thick	165.0	682.5
99	**Siltstone:** maroon	1.5	517.5
98	**Conglomerate:** 0.2 cm maximum pebble size; grading into coarse grained, maroon sandstone	3.0	516.0
97	Covered	10.5	513.0
96	**Sandstone:** maroon; medium to coarse grained; interbedded with conglomerate, 2 cm maximum pebble size; unit poorly exposed	1.5	502.5
95	Covered	4.5	501.0

Unit	Lithology	Thickness (m)	
		Unit	Total from base
94	**Sandstone:** maroon-green; medium and coarse grained; thick bedded to massive, tabular planar crossbeds; conglomeratic zones and floating pebbles	16.0	496.5
93	**Conglomerate:** grey-maroon; 8 cm maximum pebble size; massive; thin interbeds of coarse grained sandstone; pebbles of chert and impure, brown sandstone (Imina Formation); gradational upper contact	4.0	480.5
92	**Siltstone:** maroon; massive; interbedded with medium grained, maroon sandstone	4.0	476.5
91	**Conglomerate:** as Unit 93	2.0	472.5
90	**Siltstone:** maroon; sharp upper contact	6.5	470.5
89	**Sandstone:** conglomeratic; maroon; coarse grained, grading upward to medium grained; thick bedded; maroon shale partings	3.0	464.0
88	**Siltstone:** maroon; thick bedded; medium interbeds of fine grained sandstone	5.5	461.0
87	**Sandstone:** maroon; coarse grained; medium bedded; grading upward to medium grained; medium to thin bedded sandstone; poorly sorted, angular	4.5	455.5
86	Covered	16.5	451.0
85	**Conglomerate:** maroon; 5 cm maximum pebble diameter; thick bedded to massive; channels; interbedded with tabular planar crossbedded sandstone	13.0	434.5
84	**Siltstone:** maroon	2.0	421.5
83	**Sandstone:** maroon; medium grained; medium bedded; poorly sorted, conglomeratic zones	1.0	419.5
82	**Sandstone:** light grey-maroon; very coarse grained; massive, sigmoidal crossbeds; conglomeratic zones, 5 cm maximum pebble diameter	1.5	418.5
81	**Siltstone:** maroon	1.0	417.0
80	**Sandstone:** maroon; fine grained; thin to very thin bedded	1.5	416.0
79	**Sandstone:** maroon; interbedded medium and coarse grained, conglomeratic and coarse grained in lower 40 cm; planar and trough crossbeds; upper part of unit grades laterally into maroon, fine grained sandstone and siltstone	2.0	414.5
78	Covered: maroon; siltstone with sharp upper boundary	7.0	412.5
77	**Sandstone:** maroon; very fine grained; very thin bedded	1.5	405.5
76	**Sandstone:** maroon; coarse grained; massive; trace conglomerate of shale clasts at base, grades upward to maroon, medium grained sandstone; poorly sorted; angular	3.0	404.0
75	**Siltstone:** argillaceous; maroon; thin to medium bedded; shale partings, thin beds of very fine grained sandstone in uppermost part; sharp upper boundary	8.0	401.0
74	**Sandstone:** green with maroon patches; coarse grained, grading to medium grained in upper part; thick bedded, thin bedded in upper part; conglomeratic zones; very poorly sorted, angular; gradational upper contact	2.5	393.0
73	**Conglomerate:** maroon-white; 4 cm maximum pebble diameter; chert pebbles of various colours	0.5	390.5
72	**Siltstone:** argillaceous; maroon; thin to medium bedded; shale partings, minor beds of very fine grained and medium grained, very poorly sorted sandstone; unit recessive with resistant sandstone beds; sharp upper boundary	19.5	390.0
71	Interbedded and laterally interfingering maroon, argillaceous, fine grained sandstone, maroon siltstone, and coarse grained sandstone with maroon shale conglomerate	11.0	370.5
70	**Siltstone:** maroon; interbedded with medium beds of fine and medium grained sandstone; zone of very slightly calcareous, rubbly concretions in upper part	7.0	359.5
69	**Sandstone:** maroon-grey; medium grained; thin bedded; gradational lower contact	1.0	352.5
68	**Conglomerate:** sandy; light maroon; 4 cm maximum pebble diameter; massive, planar tabular crossbeds	3.5	351.5
67	**Siltstone:** maroon; interbedded with **sandstone:** ranging from very coarse grained, conglomeratic to fine grained, medium bedded	18.0	348.0
66	**Sandstone:** maroon; coarse to very coarse grained; medium to thick bedded; conglomeratic zones; (0.6 cm maximum pebble diameter)	2.0	330.0
65	**Sandstone:** silty; maroon; fine grained; medium to thick bedded, poorly sorted	2.0	328.0
64	**Sandstone:** green-white with maroon grains; medium grained; thick bedded, tangential planar crossbeds; grades upward into maroon, fine grained, thin to very thin bedded sandstone; sharp upper contact	2.0	326.0

Unit	Lithology	Thickness (m)	
		Unit	Total from base
63	**Siltstone:** maroon; fine grained, massive; in lower part coarse grained sandstone with sigmoidal crossbeds, also interbeds of coarser siltstone and fine grained sandstone	11.0	324.0
62	**Sandstone:** medium grained; maroon; thin to medium bedded; gradational upper contact	3.5	313.0
61	**Sandstone:** maroon; coarse grained; thin bedded; conglomeratic with 2.5 cm maximum pebble diameter	1.0	309.5
60	**Shale:** silty-sandy; maroon with green specks; microscopic siliceous concretions; sharp upper contact; recessive, rubbly (Mineralogical analysis, GSC loc. C-45372, see Appendix 4)	2.5	308.5
59	**Siltstone:** maroon; thin bedded; interbedded with thin beds of fine grained maroon sandstone (Mineralogical analysis, GSC loc. C-45369, see Appendix 4)	4.0	306.0
58	**Sandstone:** maroon; medium grained; medium bedded with lamination; coarse grained, well sorted sandstone at base of unit; well rounded and sorted; sharp lower boundary (Mineralogical analysis, GSC loc. C-45368, see Appendix 4)	2.0	302.0
57	**Shale:** silty; maroon	3.5	300.0
56	**Sandstone:** maroon, medium grained; medium to thick bedded, tangential planar crossbeds; basal conglomerate with 2 cm maximum pebble diameter	1.0	296.5
55	**Shale:** silty; maroon	2.5	295.5
54	**Sandstone:** laminated green and maroon; medium bedded, tangential planar crossbeds	4.5	293.0
53	Covered: probably maroon shale	14.0	288.5
52	**Sandstone:** light green; coarse to very coarse grained; thick bedded, traces of conglomeratic (0.2–0.3 cm maximum pebble diameter) crossbeds; medium bedded basal conglomerate (1 cm maximum pebble diameter)	6.5	274.0
51	Covered: probably maroon and olive-green shale	4.0	268.0
50	**Sandstone:** maroon; medium grained; medium to thin bedded	2.0	264.0
49	**Shale:** maroon; interbeds of thin bedded, fine grained, maroon sandstone	4.0	262.0
48	Covered: probably maroon shale	7.5	258.0
47	**Sandstone:** light green; coarse grained; very thick bedded to massive, large trough crossbeds; interbedded with conglomerate of green chert (1 cm maximum pebble diameter)	6.0	250.5
46	**Sandstone:** maroon; medium grained; thick bedded; interbedded with very thin bedded, fine grained, maroon sandstone	7.5	244.5
45	Covered: probably maroon siltstone and shale	5.5	237.0
44	**Sandstone:** maroon; medium grained; thick bedded, planar tabular crossbeds; interbedded with conglomerate of dark green, maroon and black chert (3 cm maximum pebble diameter)	4.0	231.5
43	**Conglomerate:** sandy; red and black chert, 2.5 cm maximum pebble diameter; medium bedded, channel	0.5	227.5
42	**Siltstone:** maroon; interbedded with medium and fine grained sandstone, in part conglomeratic; grading upward into medium grained sandstone; sharp upper boundary; unit poorly sorted	25.5	227.0
41	**Sandstone:** light green-grey; coarse grained; thick bedded; grades upward into medium bedded, medium grained sandstone	3.5	201.5
40	Covered: probably maroon shale and siltstone	3.0	198.0
39	**Sandstone:** light green; medium grained; medium bedded	1.5	195.0
38	**Sandstone:** light green; coarse grained; thick bedded to massive; zones of conglomerate; (?)anhydrite cement	6.0	193.5
37	**Sandstone:** maroon; very fine grained; thick bedded, planar crossbeds; lenses of fine grained, medium bedded sandstone most frequent in upper part of unit; poorly exposed	5.5	187.5
36	**Sandstone:** maroon; fine grained; thin bedded; very poorly sorted	1.0	182.0
35	**Sandstone:** light green; medium grained; medium bedded in lower part, thin to very thin bedded in upper part; gradational upper boundary	5.5	181.0
34	**Siltstone:** maroon; laminated; recessive unit with some thin, resistant beds	31.85	175.5
33	**Sandstone:** green with maroon specks and laminae; medium to thick bedded, sigmoidal crossbeds; sharp lower boundary	5.0	143.65
32	**Shale:** maroon; interbeds of medium grained, crossbedded sandstone grading upward into shale; green zone in uppermost part of unit	3.0	138.65
31	**Sandstone:** maroon; very fine grained; thin bedded	3.4	135.65
30	**Sandstone:** maroon; fine to medium grained; thin bedded; tangential crossbeds; poorly sorted	1.50	132.25

Unit	Lithology	Thickness (m)	
		Unit	Total from base
29	**Conglomerate:** dark green; 3 cm maximum pebble diameter; interbedded with variable sandstone and conglomeratic sandstone; green and maroon chert pebbles	3.20	130.75
28	**Shale:** maroon; sharp upper boundary	0.25	127.55
27	**Sandstone:** silty; maroon; very fine grained; massive; upper contact gradational	1.50	127.30
26	**Conglomerate:** maroon; 3 cm maximum pebble diameter; channel; upper boundary gradational	0.44	125.80
25	**Siltstone:** maroon; upper part of unit maroon shale	5.05	125.36
24	**Sandstone:** silty; maroon; medium grained; thin bedded; in upper part interbedded with shale as in Unit 25	1.30	120.31
23	**Conglomerate:** medium green; 3 cm maximum pebble diameter; grading upward into coarse grained sandstone; mostly green chert pebbles, minor maroon; gradational upper boundary	0.56	119.01
22	**Siltstone:** maroon with yellow mottles; thin bedded	5.30	118.45
21	**Sandstone:** conglomeratic; dark green with maroon; medium grained; massive, planar tabular crossbeds; sharp upper boundary	0.80	113.15
20	**Sandstone:** light grey; medium to coarse grained; thick bedded; planar tabular crossbeds; laminated with conglomerate (0.3 cm maximum pebble diameter); sharp upper boundary	1.20	112.35
19	**Conglomerate:** as Unit 23	0.35	111.15
18	**Shale:** maroon; uppermost 5-10 cm yellow; upper contact sharp, irregular	0.70	110.8
17	**Sandstone:** silty; maroon; fine grained; medium to thin bedded; angular to subangular; upper contact gradational	1.40	110.1
16	**Sandstone:** light green; medium grained; massive, laminated	0.70	108.7
15	**Sandstone:** maroon; medium grained; medium bedded; well sorted, subangular (Mineralogical analysis, GSC loc. C-45334, see Appendix 4)	1.0	108.0
14	Covered: probably very fine grained, maroon sandstone and siltstone	6.5	107.0
13	**Conglomerate** (as Unit 1): 8 cm maximum pebble diameter; sharp upper boundary	9.5	100.5
12	**Siltstone:** maroon with yellow mottles; thin bedded; rubbly	1.5	91.0
11	**Sandstone:** very light green; medium grained; massive, planar tabular crossbeds; conglomeratic and coarse grained zones (Mineralogical analysis, GSC loc. C-45333, see Appendix 4)	3.5	89.5
10	**Conglomerate** (as Unit 1): massive; channels at 63 and 66 m; interbedded with conglomeratic sandstone	33.0	86.0
9	Lense of green shale; poorly exposed	0.5	53.0
8	**Sandstone:** light green; coarse grained; medium to thick bedded; conglomeratic zones	5.0	52.5
7	**Conglomerate** (as Unit 1): 0.5 m of poorly exposed shale and sandstone at top of unit; sharp upper boundary	10.0	47.5
6	**Shale:** silty; dark grey-green	2.0	37.5
5	**Sandstone:** conglomeratic	0.5	35.5
4	**Conglomerate** (as Unit 1): 60 cm maximum pebble diameter; channels; interbeds of medium bedded, medium grained and coarse grained, conglomeratic sandstone; matrix of coarse grained, quartzitic sandstone	12.5	35.0
3	Covered: probably dark green shale	4.5	22.5
2	**Sandstone:** light green-grey; medium grained; medium bedded; interbeds of laminated, dark grey; silty shale	4.5	18.0
1	**Conglomerate:** white with black and green chert, 5 cm maximum pebble diameter; thick bedded, tangential planar crossbeds; interbeds of medium grained sandstone; matrix of coarse grained, quartzitic sandstone.	13.5	13.5
	Section underlain by green and maroon schists of Grantland Formation; unconformity within a 3 m thick covered interval.		

SECTION F1

Section F1 is located on the east side of the upper part of M'Clintock Glacier (Field Stations 27 and 43). The section was measured and described by Ulrich Mayr and D. Jones.

	Eureka Sound Formation (Tertiary)		
46	**Breccia:** limestone fragments; massive; weathers yellow.	170.0	447.3
	Hare Fiord Formation (Upper Carboniferous)		
	Contact unconformable		
45	Covered interval: rubble of dark grey, medium crystalline, thin to medium bedded dolomite; black chert nodules	15.0	277.3

Unit	Lithology	Thickness (m) Unit	Thickness (m) Total from base
44	**Limestone:** very dark grey; medium bedded; lime mudstone to skeletal wackestone; fusulinids (GSC loc. C-83369, Upper Carboniferous, Moscovian, see Appendix 3b)	3.0	262.3
43	**Covered:** in uppermost part rusty weathering dolomite, slightly calcareous, very sandy, dark grey; very fine crystalline; traces of intraformational conglomerate	7.0	259.3
42	**Sandstone:** quartzitic; medium grained; thin to very thin bedded; unit poorly exposed	2.0	252.3
41	Covered	11.0	250.3
40	**Sandstone:** medium grey; fine grained; thin bedded; subarkose	3.0	239.3
39	Covered	9.0	236.3
38	**Sandstone:** quartzitic; light grey; medium grained; medium bedded with interval parallel lamination; unit poorly exposed	10.0	227.3
37	**Siltstone:** laminated; unit poorly exposed	1.5	217.3
36	**Sandstone:** quartzitic; light grey; medium grained; medium to thick bedded; rare feldspar	2.5	215.8
35	Covered	18.0	213.3
34	**Siltstone:** shale and sandstone as in Unit 32; minor shale conglomerate; small desiccation cracks	10.0	195.0
33	**Sandstone:** medium to coarse grained; medium to thick bedded; sublitharenite	3.0	185.3
32	**Siltstone:** medium grey; very regular parallel lamination; interbedded with dark grey shale and minor, very thin bedded, medium grained sublitharenite; oscillation ripple marks	15.0	182.3
31	**Sandstone:** as in Unit 29	1.5	167.3
30	**Shale:** silty; micaceous; black	0.5	165.8
29	**Sandstone:** light green-grey; medium grained; thin bedded	2.0	165.3
28	Covered: probably interbedded shale and sandstone in 2-3 m units	15.0	163.3
27	**Sandstone:** as in Unit 21	2.0	148.3
26	**Shale:** micaceous; black	4.0	146.3
25	**Sandstone:** light grey; medium grained; thick bedded; poor exposure	2.0	142.3
24	Covered: black, silty and micaceous shale in uppermost part	5.0	140.3
23	**Sandstone:** as in Unit 21	2.5	135.3
22	**Sandstone:** medium grey-green; fine grained; very thin bedded; subarkose; unit poorly exposed (Mineralogical analysis, GSC loc. C-83360, see Appendix 4)	1.5	132.8
21	**Sandstone:** light grey-green; medium grained; thick bedded	2.0	131.3
20	Covered	7.0	129.3
19	**Limestone:** slightly dolomitic; medium grey; medium bedded; shaly laminae in upper part; crinoidal wackestone with zones of skeletal packstone, 0.7 cm maximum diameter; reefal debris.	3.8	122.3

Otto Fiord Formation
(Upper Carboniferous)

Contact sharp, conformable

Unit	Lithology	Thickness (m) Unit	Thickness (m) Total from base
18	**Anhydrite:** light grey; 5-10 cm nodules; minor gypsum	19.5	118.5
17	**Limestone:** black; medium to thin bedded; lime mudstone; rare crinoid fragments	3.0	99.0
16	**Anhydrite:** light grey; mostly nodular, interbeds of laminated, very thick bedded or distorted anhydrite; minor gypsum	13.5	96.0
15	**Dolomite:** siliceous; very light grey; thin to medium bedded; lime mudstone; abundant skeletal fragments	3.0	82.5
14	**Anhydrite:** light grey; laminated; minor gypsum	19.5	79.5
13	Covered: green and red shale, black dolomite in uppermost part	4.5	60.0
12	**Gypsum:** weathered	3.0	55.5
11	Covered: black, aphanocrystalline dolomite	1.5	52.5
10	**Gypsum:** weathered	1.5	51.0
9	Covered: black aphanocrystalline dolomite	5.0	49.5
8	**Gypsum:** white; minor interbeds of very dark grey; thin bedded dolomite	8.0	44.5
7	**Dolomite:** argillaceous, very dark grey; thin bedded	0.5	36.5
6	**Anhydrite:** medium grey; laminated to thinly laminated, slightly nodular in upper part; laminae of coarse grained shale "sand"	16.5	36.0
5	**Dolomite:** very dark grey; very fine crystalline to aphanocrystalline; thin bedded	5.5	19.5
4	**Gypsum:** weathered	2.0	14.0
3	**Sandstone:** dolomitic; medium grey; fine grained; thin bedded	1.5	12.0
2	**Dolomite:** medium dark grey; very fine crystalline; thin bedded	4.5	10.5
1	**Dolomite:** very dark grey; very fine crystalline to aphanocrystalline; thin to medium bedded.	6.0	6.0

Section underlain by several hundreds of metres of poorly exposed sandstone and black dolomite (see Section F2).

SECTION F2

This section is situated on the east side of upper M'Clintock Glacier (Field Station 26), in the vicinity of Section F1. The section was measured and described by Ulrich Mayr and D. Jones.

Section overlain by poorly exposed, thin bedded gypsum.

Otto Fiord Formation
(Upper Carboniferous)

Unit	Lithology	Thickness (m)	
		Unit	Total from base
67	**Dolomite:** silty, very slightly calcareous; very dark grey; very fine crystalline; very thin bedded	4.0	527.5
66	**Gypsum:** weathered	0.5	523.5
65	**Sandstone:** dolomitic; medium grey; very fine grained; grading into dark grey; sandy dolomite in uppermost part (Mineralogical analysis, GSC loc. C-69962, see Appendix 4)	4.5	523.0
64	**Dolomite:** very slightly calcareous; very dark grey to black; very fine crystalline; thin bedded	13.5	518.5
63	Covered: possibly gypsum, soft green shale and black shale	8.5	505.0
62	**Gypsum:** nodular, brecciated	1.5	496.5
61	**Breccia:** black limestone in gypsum matrix	1.5	495.0
60	**Limestone:** argillaceous; very dark grey to black; thin bedded; upper boundary gradational	3.5	493.5
59	Covered	6.0	490.0
58	**Sandstone:** calcareous; black; fine grained; thin bedded	1.0	484.0
57	**Siltstone:** medium green to medium grey; bedding very regular, thin to very thin, ripple marks; bed of dark grey shale in middle part of unit; weathers platy, brown	6.0	483.0
56	**Shale:** very calcareous; very dark grey; thinly laminated; interbedded with thin beds of calcareous, very dark grey siltstone with syneresis cracks	8.2	477.0
55	**Sandstone:** light grey-brown; fine to medium grained; thin bedded, ripple marks	0.8	468.8
54	**Dolomite:** shaly, very slightly calcareous; very dark grey; aphanocrystalline; very thin bedded; bed of gypsum breccia with dolomite fragments in central part of unit	1.5	468.0
53	**Siltstone:** micaceous, calcareous; very light green; very thin bedded; interbedded with abundant green shale	7.5	466.5
52	Covered: probably green shale and siltstone	4.5	459.0
51	**Siltstone** (as in Unit 53): bed of light green, very fine grained sandstone at top	3.0	454.5
50	Covered: possibly slightly calcareous, black, aphanocrystalline dolomite; very thin bedded; fractured with anhydrite	4.5	451.5
49	**Siltstone** (as in Unit 53): interbedded with minor light green, laminated shale; lower boundary gradational	7.5	447.0
48	**Shale:** light green; thin bedded, nodular; gypsum along veins and bedding planes (Mineralogical analysis, GSC loc. C-69960, see Appendix 4)	6.0	439.5
47	Covered: at 393 m a small outcrop of very dark grey, medium grained, very thin bedded sandstone	75.0	433.5
46	**Sandstone:** medium grey; interbedded fine and medium grained; thin bedded, trough crossbeds; ripple marks	22.5	358.5
45	Covered	9.5	336.0
44	**Sandstone** (as in Unit 46): minor coarse grained interbeds, 1.5 m interbed of dark grey; silty, micaceous shale; large (1 m) sets of planar tabular crossbeds	37.0	326.5
43	Covered	6.5	289.5
42	**Sandstone:** as in Unit 46	11.0	283.0
41	**Sandstone:** medium grey; medium to coarse grained; medium bedded; fining upward sequence with shale conglomerate at base and 6 cm of dark, olive-green shale at top	0.5	272.0
40	**Sandstone:** medium grey; medium grained; very thin bedded, syneresis cracks; interbedded with shale and siltstone; poorly sorted	1.5	271.5
39	**Sandstone** (as in Unit 38): poorly exposed; parting lineations; sublitharenite	19.5	270.0
38	**Sandstone:** dark grey; medium grained; very thin bedded, rare planar, tangential crossbeds (set thickness 30 cm), small channel with intraformational conglomerate	4.5	250.5
37	**Siltstone:** dark grey; thin bedded, ripple marks	7.5	246.0
36	**Sandstone:** very dark grey; fine grained; thin to very thin bedded	3.0	238.5
35	**Siltstone:** slightly calcareous; dark grey with green mottles; thin bedded; shale flakes throughout	9.5	235.5
34	Covered	2.5	226.0
33	**Sandstone:** very dark grey; very fine grained; very thin bedded; fine grained sandstone in uppermost part	2.0	223.5
32	Covered	5.5	221.5

Unit	Lithology	Thickness (m)	
		Unit	Total from base
31	**Sandstone:** very dark grey; fine grained; medium bedded, vague crossbeds; thin interbeds of black shale	6.0	216.0
30	**Sandstone** (as in Unit 29): poorly exposed; parting lineation	12.0	210.0
29	**Sandstone:** very slightly calcareous; very dark grey; very fine grained; thin bedded, regular laminated; channel at 195 m	5.0	198.0
28	Covered	13.0	193.0
27	**Siltstone:** very slightly calcareous; very dark grey; thin bedded	3.0	180.0
26	Covered	3.0	177.0
25	**Sandstone:** very dark grey; very fine grained; very thin bedded; thin calcareous beds	7.5	174.0
24	Covered: very dark grey, fine grained, thin to very thin bedded sandstone	9.5	166.5
23	**Sandstone:** very dark grey; medium grained; medium bedded; very shallow trough crossbeds	2.5	157.0
22	Covered: green siltstone with ripple marks; possibly some black shale	9.5	154.5
21	**Siltstone:** very slightly calcareous; grey-green; irregularly thin bedded	1.0	145.0
20	**Shale:** dark grey	4.5	144.0
19	**Sandstone:** very dark grey; very fine grained; thick bedded	1.5	139.5
18	Covered: dark grey shale	3.0	138.0
17	**Sandstone:** dark grey; coarse grained; thick to very thick bedded, trough crossbeds; conglomerate (0.5 cm granule diameter) in lower part, shale clasts throughout sandstone	3.5	135.0
16	**Sandstone:** very dark grey; fine grained; very regular laminated, parting lineation; grades upward into coarse grained, black siltstone	2.5	131.5
15	Covered: in lower part dark grey shale; ostracodes at 91.5 m	41.2	129.0
14	**Sandstone:** calcareous; medium to dark grey, coarse grained; thick bedded, trough crossbeds	2.0	87.8
13	Covered: mostly dark grey shale	3.3	85.8
12	**Sandstone:** slightly calcareous; medium grey with dark grey mottles; fine grained; thin bedded, churned	2.0	82.5
11	**Shale:** very dark grey	2.0	80.5
10	**Sandstone:** quartzitic; very dark grey; medium grained; thick bedded, pyritic	1.2	78.5
9	**Siltstone:** very calcareous; black; medium bedded; weathers brown	0.3	77.3
8	**Siltstone:** very slightly calcareous; black; very thin bedded, laminated	1.0	77.0
7	Interval mostly covered: black, medium grained sandstone grades upward into fine grained sandstone and siltstone (Mineralogical analysis, GSC loc. C-69953, see Appendix 4)	6.5	76.0
6	**Sandstone:** slightly silty; very dark grey; medium grained; thin bedded; abundant specks of weathered pyrite; unit poorly exposed	6.5	69.5
5	**Sandstone:** silty; very dark grey; medium grained; thin bedded, crossbeds	4.5	63.0
	Covered: mostly soft, laminated, olive-green shale	11.0	58.5
3	**Sandstone:** dark grey; very fine grained; thick bedded; weathered pyrite specks	3.0	47.5
2	**Shale:** silty and very slightly calcareous; dark grey; thin to medium bedded; interbedded with black, argillaceous lime mudstone with rare small crinoids; interbedded with dark grey dolomitic siltstone; interbedded with dark grey papery shale; interbedded with **sandstone:** quartzitic; light grey; medium to coarse grained; thick bedded with very thin interval bedding, vague crossbeds (Mineralogical analysis, GSC loc. C-69950, see Appendix 4)	17.5	44.5
1	**Shale:** soft; olive-green; interbedded with minor green-black shale and resistant argillaceous and calcareous, dark grey; fine grained siltstone; unit poorly exposed.	27.0	27.0
	Underlying beds not exposed.		

SECTION F3

This section is situated on the east side of upper M'Clinlock Glacier, (Field Stations 24 and 25) about 6 km north of Sections F1 and F2. The section was measured and described by Ulrich Mayr and D. Jones.

Section overlain by Otto Fiord evaporites; contact not examined.

Borup Fiord Formation
(Upper Carboniferous)

52	**Shale:** green-grey; interbedded with minor siltstone. Thickness estimated, interval not examined	480.0	924.0
51	**Shale:** dark maroon; calcareous with non-calcareous zones and laminae; gypsum intrusions along joints	25.7	444.0
50	**Siltstone:** argillaceous; green with maroon mottles; very thin bedded	0.3	418.3
49	**Shale** (as in Unit 51): mostly noncalcareous	7.2	418.0
48	**Siltstone:** as in Unit 50	1.3	410.8

Unit	Lithology	Thickness (m)	
		Unit	Total from base
47	**Shale:** slightly silty and calcareous; medium brown and dark maroon; ripple marks; joints filled with anhydrite; unit poorly exposed and partly covered	43.5	409.5
46	Covered: shale	7.5	366.0
45	**Siltstone:** calcareous; red-brown with green mottles; thick bedded, ripple marks; gypsum intrusions	2.0	358.5
44	**Shale:** maroon; very abundant small spherical stromatolites	9.5	356.5
43	**Siltstone:** as in Unit 45	3.5	347.0
42	Covered: light green; calcareous shale	7.5	343.5
41	**Shale:** maroon; abundant small, spherical stromatolites; poor exposure	1.5	336.0
40	**Siltstone:** bright green; thin bedded; thick bedded in upper part; (?)bioturbation; gradational lower contact	5.0	334.5
39	**Shale:** calcareous and silty; light green with some maroon zones; massive with lamination; silt content decreasing upward; thin interbed of light grey; fine grained quartzite; gypsum along joints	21.2	329.5
38	**Siltstone:** slightly calcareous; red and green mottled; thick bedded, bioturbation	0.8	308.3
37	**Shale:** slightly calcareous; maroon	11.0	307.5
36	**Siltstone:** argillaceous; very slightly calcareous; red and green mottles; thin bedded, ripple marks	4.5	296.5
35	**Shale:** calcareous; soft; light green with minor light brown-green zones; ripple marks; some resistant silty zones in lower part; pyrite nodules; colour changes to maroon in uppermost 5 m	40.5	292.0
34	**Quartzite:** light green; medium grained; thick bedded, vague crossbeds; vuggy zones, appears to fine upward	4.0	251.5
33	(Felsenmeer) **Shale:** calcareous; light green; interbedded with **siltstone:** slightly calcareous; medium green; fine grained; thin bedded, ripple marks; very hard	6.0	247.5
32	**Shale:** calcareous; light green; recessive, with two resistant, silty beds	5.5	241.5
31	**Sandstone:** slightly calcareous; light brown; very fine grained; thin to very thin bedded; very abundant ripple marks; shaly intervals and zones of maroon weathering	8.0	236.0
30	**Shale:** calcareous; light green	7.0	228.0
29	**Sandstone** (as in Unit 31): ripple marks and shallow, small trough crossbeds; upper boundary sharp and with desiccation cracks, lower boundary gradational; interbeds of bright green shale	5.5	221.0
28	**Shale:** calcareous; very light green	3.0	215.5
27	**Siltstone:** very argillaceous and calcareous; medium grey; very fine grained; very thin bedded, upper boundary sharp and possibly with desiccation cracks, lower boundary gradational	0.2	212.5
26	**Shale:** calcareous; zones of green and maroon colour	23.3	212.3
25	**Siltstone:** calcareous to very calcareous; light green; very thin bedded; upper boundary sharp; partings of green shale, gypsum intrusions along bedding planes	4.2	189.0
24	**Siltstone:** calcareous; light green; thick bedded, lower boundary gradational	0.8	184.8
23	**Shale:** calcareous; light green; maroon zones in upper part; interbedded with rare, thin beds of **sandstone:** calcareous; fine grained; unit poorly exposed	37.0	184.0
22	**Shale:** calcareous; maroon; upper boundary gradational	0.5	147.0
21	**Siltstone:** slightly calcareous; green and maroon; thin bedded	1.0	146.5
20	Covered: probably mostly light green, calcareous shale; at 97.5 m a thin bed of black lime mudstone; scree of calcareous siltstone, black shale, and lime mudstone	48.7	145.5
19	Single bed of **sandstone:** calcareous; white; fine grained; laminated, flute marks	0.3	96.8
18	**Shale:** calcareous; green	7.5	96.5
17	**Shale:** maroon; interbedded with **sandstone:** very slightly calcareous; green, very fine grained, ripple marks; unit poorly exposed	3.5	89.0
16	**Shale:** light green	7.0	85.5
15	**Sandstone:** green; fine grained; thin bedded, ripple marks (Mineralogical analysis, GSC loc. C-69939, see Appendix 4)	2.0	78.5
14	**Shale:** slightly calcareous; maroon; lower boundary gradational	1.5	76.5
13	**Shale:** calcareous; green; interbedded with yellow-green argillaceous siltstone and thin zones of black, calcareous shale; unit poorly exposed	48.0	75.0
12	**Siltstone:** calcareous; green-brown; thin bedded, abundant ripple marks	0.7	27.0
11	**Shale:** calcareous; green	2.3	26.3
10	**Siltstone:** argillaceous and slightly calcareous; green; massive at base; thin bedded at top, vague tangential, planar crossbeds; desiccation cracks in upper part; interbedded with green shale	4.5	24.0
9	**Shale:** very slightly calcareous; maroon; upper boundary gradational	1.0	19.5

Unit	Lithology	Thickness (m)	
		Unit	Total from base
8	**Siltstone:** calcareous; maroon; thin bedded with regular lamination and ripple marks; interbedded with thin to very thin bedded maroon shale	2.2	18.5
7	**Siltstone:** calcareous; maroon; gradational to **sandstone:** very fine grained; thick bedded, large planar, sigmoidal crossbeds	1.3	16.3
6	Covered: green shale; calcareous	1.2	15.0
5	**Sandstone:** slightly quartzitic and calcareous; brown; fine grained; thin bedded, desiccation cracks; green siltstone in upper part	0.3	13.8
4	**Siltstone:** maroon; regularly thin bedded; climbing ripples	1.5	13.5
3	**Siltstone:** maroon; thin to thick bedded; channelled	3.0	12.0
2	**Shale:** maroon; laminated, ripple marks; at top channel with fine grained, maroon sandstone, trough crossbeds	1.0	9.0
1	**Siltstone:** maroon; thin bedded with regular lamination in individual beds, single thick bed with tangential trough crossbeds.	8.0	8.0
	Sections start in core of anticline, underlying beds not exposed.		

SECTION G

This section is situated at the end of a large U-shaped valley on the east side of M'Clintock Glacier (Field Station 41). The section was measured and described by Ulrich Mayr and D. Jones.

Nansen Formation
(Upper Carboniferous)

Top of outcrop

Unit	Lithology	Thickness (m)	
		Unit	Total from base
37	**Dolomite:** medium bedded; thin beds of white chert	23.0	435.0
36	**Dolomite:** light grey; medium crystalline; thin bedded; beds of skeletal material, beds and nodules of black chert; fusulinids (GSC loc. C-83345, (?)Upper Carboniferous, Moscovian, see Appendix 3b)	7.0	412.0
35	**Dolomite:** medium grey; fine crystalline; medium bedded; (?)algal grainstone; weathers very light grey	83.0	405.0
34	**Dolomite:** dark grey; fine crystalline; thin bedded with wavy bedding plane; abundant black chert nodules	7.0	322.0
33	Covered	50.0	315.0
32	**Dolomite:** light grey; fine crystalline; thick bedded; abundant white chert nodules	2.0	265.0
31	**Dolomite:** silty, argillaceous; light grey; fine crystalline; thin bedded; intraclastic; platy weathering, poor exposure	4.0	263.0
30	**Dolomite:** black; fine to very fine crystalline; thin bedded; (?)algal; lenses of black chert	4.0	259.0
29	Covered	3.0	255.0
28	**Dolomite:** light grey; medium crystalline; medium and thin bedded; skeletal packstone; chert nodules; abundant crinoid fragments	3.0	252.0
27	Covered	4.0	249.0
26	Sill	3.0	245.0
25	**Limestone:** dolomitic; light grey; medium bedded; skeletal grainstone with silicified cement, coarse calcarenite; foraminifers, calcareous algae, corals, crinoid fragments (GSC locs. C-83339, C-83340, Late Carboniferous, Moscovian, see Appendix 3b)	11.0	242.0
24	Covered	6.0	231.0
23	**Dolomite** (as below in Unit 20): rubbly outcrop	12.0	225.0
22	**Dolomite:** siliceous; light grey; fine crystalline; medium bedded; (?)burrowed	3.0	213.0
21	Covered	6.0	210.0
20	**Dolomite:** slightly calcareous; medium grey; medium bedded; chert nodules; zones of scattered skeletal debris	12.0	204.0
19	Covered	33.0	192.0
18	**Dolomite:** cherty; dark grey; medium crystalline; medium bedded	2.0	159.0
17	Covered	17.0	157.0
16	**Dolomite:** dark grey; medium crystalline; thick bedded with minor thin beds; burrowed; medium grained; grainstone; relict texture; scattered brachiopods and crinoid fragments, coral zone at 87.5 m (GSC loc. C-83334, Late Carboniferous, see Appendix 3b)	74.5	140.0
15	**Dolomite:** light grey; very fine crystalline; massive	5.5	65.5
14	**Dolomite:** very slightly calcareous; dark grey; medium crystalline; thick to very thick bedded; burrowed	16.5	60.0
13	**Dolomite:** as below in Unit 9	1.0	43.5
12	**Dolomite:** very dark grey; medium crystalline; medium to thick bedded; gradational lower contact; discontinuous beds of black chert	1.5	42.5
11	**Dolomite:** as below in Unit 9	2.0	41.0

		Thickness (m)	
Unit	Lithology	Unit	Total from base
10	**Dolomite:** light grey; medium crystalline; medium to thick bedded, sharp upper contact; medium grained grainstone relict texture; trace of silt	5.0	39.0
9	**Dolomite:** siliceous, very dark grey; medium to coarse crystalline; thin bedded; gradational upper contact; medium grained; uniform grainstone relict texture	4.0	34.0
8	**Dolomite:** calcareous, silty, sandy; maroon, medium crystalline; very thin bedded and laminated; rock fragments, mica, feldspar, quartz; maroon shale in lower part; unit poorly exposed	2.0	30.0
7	**Dolomite:** siliceous; light green-grey; medium crystalline; medium to thin bedded, wavy bedding planes; abundant white chert nodules; brachiopods common	11.0	28.0
6	**Dolomite:** slightly silty and micaceous, medium green, fine crystalline; medium to thick bedded, interval wavy thin bedding, slightly nodular; skeletal fragments; weathers light red-brown; scattered solitary corals	5.0	17.0
5	**Dolomite:** slightly silty; light grey; medium crystalline; thin bedded, partings of green shale; relict texture of pelletal grainstone; interbedded with dark grey, fine crystalline dolomite	2.0	12.0
4	**Dolomite:** very hard; light yellow-green, medium to coarse crystalline; massive; lower contact gradational; vuggy, relict texture of coarse grained grainstone	2.75	10.0
3	**Dolomite:** medium grey-green; fine crystalline; thin bedded; burrowed; floating quartz grains, interbeds of chert; recessive	1.25	7.25
2	Covered	1.0	6.0
1	**Dolomite:** very sandy and silty; light grey; thick bedded with wavy bedding planes; quartz, rock fragments, various feldspars; grading to fine grained, dolomitic sandstone in upper part; brachiopods in scree (GSC loc. C-83322, Early Namurian(?), see Appendix 3b).	5.0	5.0
	Underlying beds: folded lower Paleozoic rocks.		

SECTION H

Section H is situated on the east side of the head of M'Clintock Inlet (Field Station 54). It was measured and described by Ulrich Mayr and J. Pulishy.

Section overlain by Triassic sandstone and limestone, contact not exposed.

		Thickness (m)	
Unit	Lithology	Unit	Total from base
	Assistance Formation (Permian)		
6	Covered: trace of red sandstone in scree	90.0	288.0
5	**Limestone:** sandy; medium grey-brown; thin bedded; solitary corals common	1.5	198.0
4	Covered: probably similar to Unit 5.	52.5	196.5
	Total thickness of Assistance Formation 144 m		
	Tanquary Formation (Permian to Upper Carboniferous)		
	Contact not exposed		
3	**Limestone:** light brown; massive; skeletal grainstone; chert nodules; corals common	21.0	144.0
2	Unit mostly covered: argillaceous, light green-grey, thin to very thin bedded limestone; abundant bryozoans on bedding planes	25.5	123.0
1	**Limestone:** light grey; very thick bedded; skeletal grainstone, coarse calcarenite, calcirudite in upper part; chert nodules; solitary corals common.	97.5	97.5
	Underlying beds not exposed.		

SECTION I

This section was measured in steeply dipping beds within the Porter Bay Fault Zone (Field Stations 47 and 48). The section was described by Ulrich Mayr and D. Jones.

		Thickness (m)	
Unit	Lithology	Unit	Total from base
	Assistance Formation (Permian)		
	End of exposure		
19	**Sandstone:** very calcareous; dark grey; very fine grained; medium bedded; glauconitic; abundant corals and bryozoans	57.0	603.0
18	**Sandstone:** calcareous and siliceous; dark grey; very fine grained (Mineralogical analysis, GSC loc. C-83477, see Appendix 4)	1.0	546.0
17	**Sandstone:** as in Unit 15	10.0	545.0
16	**Limestone:** slightly siliceous; grey; medium bedded; skeletal grainstone of mostly bryozoan fragments, medium calcarenite	3.0	535.0
15	**Sandstone:** calcareous; dark grey; very fine grained; irregularly thin bedded; weathers orange; very fossiliferous (Mineralogical analysis, GSC loc. C-83474, see Appendix 4)	20.0	532.0

Unit	Lithology	Thickness (m)	
		Unit	Total from base
14	**Limestone:** siliceous, very sandy; very dark grey; thin bedded; in part skeletal packstone, sponge spicules; unit exposed intermittently, lower contact very gradational (GSC loc. C-83473, Permian, late Leonardian to early Wordian, see Appendix 3b) (Mineralogical analysis, GSC loc. C-83471, see Appendix 4)	54.0	512.0
13	**Sandstone:** siliceous, calcareous, argillaceous; dark grey; very fine grained; medium to thin bedded; thin interbeds of black shale; quartzwacke; abundant trace fossils and burrows; abundant small *Zoophycos* sp.; lower contact very gradational	21.0	458.0
12	**Sandstone:** argillaceous and calcareous; black; very fine grained; thin bedded and laminated; quartzwacke, gradational to argillaceous limestone; small *Zoophycos* sp., lower contact gradational	12.0	437.0
11	Poorly exposed unit: mostly black shale and siltstone, dark grey-brown chert at base; unit faulted and folded; thickness estimated.	100.0	425.0
	Belcher Channel Formation (Permian to Upper Carboniferous) Contact sharp, disconformable		
10	Unit mostly covered or inaccessible: probably similar to Unit 9	105.0	325.0
9	**Limestone:** silty and sandy; dark brown-grey; massive to thick bedded; siliceous zones; skeletal wackestone to grainstone; solitary corals abundant, *Syringopora* type corals common; foraminifers (GSC locs. C-83463 and C-83464, Early Permian, Asselian, see Appendix 3b)	114.0	220.0
8	Covered: probably similar to Unit 5, sandstone interbeds	28.0	106.0
7	**Limestone:** very sandy; dark grey; medium bedded; skeletal wackestone and packstone; unit poorly exposed	17.0	78.0
6	**Limestone:** silty; dark grey; thick bedded; skeletal wackestone and packstone, medium calcarenite; hardground with abundant corals	12.0	61.0
5	**Siltstone:** argillaceous and dolomitic; medium grey-brown; laminated; nodules of limestone; corals	8.0	49.0
4	Poorly exposed unit: fine grained sandstone, argillaceous limestone and shale	13.0	41.0
3	**Limestone:** sandy, siliceous and dolomitic; medium grey; very thin bedded; skeletal wackestone; at base of unit single thick bed of skeletal grainstone with abundant small solitary corals in growth position	7.0	28.0
2	Sill	6.0	21.0
1	**Limestone:** very sandy; light grey; massive; skeletal packstone and grainstone; poor exposure with possible interbeds of black and maroon shale; foraminifers (GSC loc. C-83452, Early Permian, see Appendix 3b).	15.0	15.0

SECTION K

This section was measured in overturned beds in the cliffs along upper Clements Markham River (Field Stations 33 and 44). The section was described by Ulrich Mayr, R. Gardiner, and D. Jones.

Section ends below Cresent Glacier Thrust Fault, hanging wall of thrust contains Otto Fiord Formation.

Mount Bayley Formation
(Permian to Upper Carboniferous)

Unit	Lithology	Thickness (m)	
		Unit	Total from base
96	**Breccia:** 5 cm maximum pebble diameter; 50% dark carbonate and 50% light yellow carbonate pebbles; unit lensoid, grades laterally into light pebble breccia	1.5	1175.5
95	**Breccia:** light yellow; massive; limestone pebbles, very poorly sorted, high amount of matrix	16.5	1174.0
94	**Limestone:** light grey; lime mudstone; fractured and brecciated	9.0	1157.5
93	**Dolomite:** slightly silty, impure; light grey; massive, slightly fractured; dolosiltite; pockets of well sorted, very angular breccia	7.5	1148.5
92	Covered	24.0	1141.0
91	**Breccia:** 4 cm maximum clast diameter; abundant matrix; interfingers laterally with **limestone:** light grey; lime mudstone; thin bedded and fractured	7.5	1117.0
90	**Limestone:** light grey; massive; interbedded with **breccia:** massive; 1 cm maximum clast diameter; abundant cement	4.5	1109.5
89	**Limestone:** light grey; massive, fractured; lime mudstone	1.5	1105.0
88	**Breccia:** 10 cm maximum clast diameter; massive; high amount of matrix, pebbles of yellow-grey limestone, traces of maroon siltstone and maroon limestone; conglomeratic in upper part	9.0	1103.5
87	**Dolomite:** silty; yellow; thin bedded; dolosiltite; conglomeratic in upper part	7.5	1094.5
86	**Dolomite:** silty; yellow; fine to very fine crystalline, massive, vuggy; large grey "nodule" of coarse grained siltstone along bedding plane fault	9.0	1087.0
85	Covered	42.0	1078.0
84	**Breccia** (as in Unit 94): 1 cm maximum pebble diameter	12.0	1036.0

Unit	Lithology	Thickness (m)	
		Unit	Total from base
83	Covered	15.0	1024.0
82	**Breccia:** as in Unit 94	6.0	1009.0
81	**Dolomite:** slightly silty; light grey; very fine crystalline; massive, fractured in upper part	9.0	1003.0
80	Covered	15.0	994.0
79	**Dolomite:** medium grey; very fine crystalline; massive	6.0	979.0
78	Covered	9.0	973.0
77	**Limestone:** light grey; massive; skeletal rudstone; abundant small gastropods, brachiopod and phylloid algal fragments (GSC loc. C-70258, Upper Carboniferous, late Moscovian, see Appendix 3b)	7.5	964.0
76	**Dolomite:** calcareous; light grey; fine crystalline; massive	4.5	956.5
75	Covered	31.5	952.0
74	**Limestone:** light grey with white cement mottles; vuggy; skeletal wackestone; brachiopods, bryozoans	9.0	920.5
73	**Dolomite** (as in Unit 76): some brecciation	7.5	911.5
72	**Limestone:** light grey; massive; skeletal wackestone; rare brachiopods and crinoids	6.0	904.0
71	Covered	6.0	898.0
70	**Limestone:** dolomitic; light grey; massive; lime mudstone	12.0	892.0
69	**Limestone:** as in Unit 74	3.0	880.0
68	**Breccia:** dolomitic; massive; clasts leached; in lower part grading into **dolomite:** slightly argillaceous and calcareous; medium grey	22.5	877.0
67	**Dolomite:** siliceous; medium brown-grey; very fine crystalline; thin bedded; gradational to chert	1.5	854.5
66	**Dolomite:** calcareous; very light grey; very fine crystalline; thin bedded	6.0	853.0
65	**Siltstone:** dolomitic; medium grey; medium bedded	9.0	847.0
64	**Siltstone:** dolomitic; yellow with maroon and green; thin bedded	4.5	838.0
63	**Dolomite:** medium grey; aphanocrystalline; thin to medium bedded; traces of intraformational conglomerate in upper part	7.5	833.5
62	**Breccia:** light grey-brown; 3 cm maximum clast diameter; massive; dolomite pebbles in calcareous matrix, poorly sorted	30.0	826.0
61	**Siltstone:** dolomitic; light yellow; medium bedded	3.0	796.0
60	Inaccessible: thin bedded	1.5	793.0
59	**Breccia:** as in Unit 62	5.0	791.5
58	**Siltstone:** argillaceous and dolomitic, slightly calcareous, light grey; thin bedded; in upper part **dolomite:** medium grey; very fine crystalline, thin bedded, chert lenses and interbeds	4.5	786.5
57	**Breccia** (as in Unit 62): grading into zones of fractured dolomite	22.5	782.0
56	**Dolomite:** yellow; very fine crystalline; medium bedded; silty laminae	1.5	759.5
55	**Dolomite** (as above in Unit 56): thin bedded	1.5	758.0
54	**Dolomite** (as above in Unit 56): massive	3.0	756.5
53	**Dolomite** (as above in Unit 56): medium bedded	1.5	753.5
52	Covered and inaccessible	21.0	752.0
51	**Limestone:** dolomitic; light grey; massive; lime mudstone; traces of small crinoids; grades upward into **dolomite:** calcareous; light grey; aphanocrystalline; massive	19.5	731.0
50	**Chert:** light grey-brown; thin bedded; interbedded with **dolomite:** yellow, very fine crystalline; medium bedded; sponge spicules	7.5	711.5
49	**Volcanic rock:** very thick bedded, pillow structures; interbeds and lenses of volcanic conglomerate; tholeiitic basalt (Mineralogical analysis, GSC loc. C-70249, see Appendix 4)	75.0	704.0
48	**Breccia:** chaotic at base, >1.5 m boulder diameter, massive in higher part; >50% volcanic fragments; slumping and contorted bedding in lowermost part	10.0	629.0
47	**Dolomite:** slightly siliceous; dark grey; fine to very fine crystalline; thin bedded to laminated grading into medium bedded, medium grey dolomite in lower part; sponge spicules	5.0	619.0
46	Covered	21.0	614.0
45	**Dolomite** and **breccia** (interbedded)		
	Dolomite: sandy; dark grey; fine crystalline; thin bedded		
	Breccia: light grey-yellow; massive fragments of fine and very fine dolomite; quartz grains between dolomite fragments		
	3 m thick beds of breccia, 2.5 m thick units of thin bedded dolomite; base of breccia beds sharp, upper contact with dolomite gradational; also rare interbeds of skeletal grainstone	96.0	593.0
44	**Breccia:** massive; weathers very light yellow; poorly exposed interval.	32.0	497.0

Unit	Lithology	Thickness (m)	
		Unit	Total from base
	Antoinette Formation (Upper Carboniferous) Contact sharp, conformable		
43	**Dolomite:** silty and slightly sandy; medium grey; fine crystalline; thin bedded; interbedded with minor shale and light pink-green, crinoidal grainstone	8.0	465.0
42	**Dolomite:** dark grey; medium crystalline; medium bedded with wavy, thin bedded and laminated interval; (?)cryptalgal; chert nodules; rare colonial and solitary corals	57.0	457.0
41	Covered	7.0	400.0
40	**Dolomite:** very slightly calcareous; dark grey; fine crystalline; medium to thick bedded; very uniform in upper part; grading to medium grey; medium crystalline, massive dolomite in lower part; traces of skeletal clasts	103.0	393.0
39	Covered	30.0	290.0
38	**Dolomite:** silty and micaceous; light green; thin bedded with interval lamination; dolosiltite	2.0	260.0
37	**Dolomite:** dark grey; medium to coarse crystalline; thin to medium bedded; minor green shale partings	16.0	258.0
36	**Sandstone:** dolomitic; light grey-green; fine grained; very thin bedded to laminated; sublitharenite	1.0	242.0
35	**Sandstone:** dark grey; coarse grained; medium bedded; poorly sorted	1.0	241.0
34	**Dolomite:** as in Unit 37	2.0	240.0
33	**Siltstone:** medium grey; thin bedded; weathers maroon	1.0	238.0
32	**Dolomite:** sandy; dark grey; medium crystalline; thick bedded	2.0	237.0
31	**Sandstone:** medium grey; very fine grained; very regularly thin bedded; lithic greywacke; platy weathering	2.0	235.0
30	**Shale:** dolomitic; dark grey; sharp upper and lower contact	1.0	233.0
29	**Dolomite:** calcareous; medium crystalline; thick bedded with nodular interval; thin beds; interbeds of green shale	9.0	232.0
28	Covered: probably black shale and siltstone	2.0	223.0
27	**Sandstone:** dark grey; medium grained; medium bedded with intervals, of thin bedding; very sharp upper and lower contact; sublitharenite	3.0	221.0
26	**Dolomite:** very dark grey; thick bedded; interbedded with **sandstone:** dolomitic, medium grained; medium bedded; foraminifers (GSC loc. C-70316, Upper Carboniferous, late Moscovian, see Appendix 3b)	9.0	218.0
25	**Shale:** olive-green; slaty; abundant horizontal burrows	6.0	209.0
24	**Siltstone:** dolomitic; light green-grey; thin bedded; in lower part interbedded with green shale	7.0	203.0
23	**Dolomite:** sandy; dark grey; medium bedded; grades to sandstone in lower part; sharp lower contact	6.0	196.0
22	**Sandstone:** dolomitic; dark grey; fine grained; medium bedded	6.0	190.0
21	**Sandstone:** dolomitic; medium grained; medium bedded; poorly sorted; weathers orange	12.0	184.0
20	**Sandstone:** dolomitic; light green-grey; fine grained; thin bedded; litharenite; interbedded with green shale and siltstone, interbeds increase downward, sharp lower contact	6.0	172.0
19	**Sandstone:** dolomitic; dark grey; medium grained; medium bedded; conglomeratic zone	13.0	166.0
18	**Sandstone:** light green-grey; very fine grained; thin bedded, some lamination grading into black shale in lower part; unit poorly exposed	8.0	153.0
17	**Dolomite:** black; very fine crystalline; massive; sharp upper and lower boundary.	2.0	145.0
	Canyon Fiord Formation (Upper Carboniferous) Contact sharp, conformable		
16	**Sandstone:** very light grey; fine grained in upper part, very fine grained in lower part; thick bedded; subarkose; quartzitic, minor dolomitic and sericitic cement; interbedded with minor green shale; weathers brown	27.0	143.0
15	**Siltstone:** maroon	4.0	116.0
14	**Sandstone:** maroon; very fine to medium grained; thin bedded; conglomerate at base; sublitharenite	0.5	112.0
13	**Sandstone:** green; coarse grained; thick bedded to massive	4.5	111.5
12	**Conglomerate:** massive; clasts of green shale and chert	1.0	107.0

Unit	Lithology	Thickness (m)	
		Unit	Total from base
11	**Sandstone:** green; coarse grained; massive; low angle planar crossbeds; sublitharenite; shale chips on bedding planes	3.0	106.0
10	**Sandstone:** light green; medium grained with very fine grained intervals; thick bedded; interbeds of green and maroon siltstone; sublitharenite; lower contact gradational	33.0	103.0
9	**Siltstone:** maroon and green	7.0	70.0
8	**Sandstone:** conglomeratic; coarse to very coarse grained; massive to very thick bedded; pebbles of green and black chert, white quartz, 5 cm maximum diameter; very resistant unit	9.0	63.0
7	**Sandstone:** quartzitic; maroon; medium and coarse grained; thick bedded	5.0	54.0
6	Three fining-upward cycles: green, conglomeratic sandstone at base, maroon shale at top; unit poorly exposed	27.0	49.0
5	**Sandstone:** maroon and green, medium and coarse grained; thin bedded; conglomeratic zones; sublitharenite	7.0	22.0
4	**Shale:** silty, micaceous; maroon	3.0	15.0
3	**Conglomerate:** maroon; varicoloured pebbles, 4 cm maximum pebble diameter; very sharp contacts	3.0	12.0
2	**Shale:** maroon; grades to **sandstone:** maroon; medium grained, in lower part; gradational lower boundary	3.0	9.0
1	**Sandstone:** conglomeratic; coarse grained; thick bedded to massive.	6.0	6.0

Section is underlain stratigraphically by at least 100 m more of the Canyon Fiord Formation, consisting of fining-upward cycles, 6 to 8 m thick.

SECTION L1

This section was measured in overturned beds along Clements Markham River (Field Station 45). The section was described by Ulrich Mayr and D. Jones.

End of outcrop

Otto Fiord Formation
(Upper Carboniferous)

Unit	Lithology	Thickness (m)	
		Unit	Total from base
8	**Shale:** very soft; medium grey; minor thin interbeds of **sandstone:** light grey; coarse grained; very impure with high amount of carbonate clasts, flute casts; rare thin interbeds of laminated siltstone and aphanocrystalline, black dolomite; shale weathers papery; poor exposure	330.0	742.0
7	Covered: black shale(?)	70.0	412.0
6	**Shale:** silty; black; abundant intervals (2-5 m thick) of **sandstone:** in upper part of unit black; medium grained; thin bedded, crossbedded; dolomitic, oncolitic; in lower part of unit medium green-grey; medium to coarse grained; thick bedded, channelled and crossbedded; lenses of evaporite along strike.	199.0	342.0

(?)Otto Fiord Formation

Unit	Lithology	Thickness (m)	
		Unit	Total from base
5	**Sandstone:** light green; medium grained; thick bedded(?)	29.0	143.0
4	**Shale:** variably silty; light green; foliated	26.0	114.0
3	**Siltstone:** argillaceous; purple; foliated	36.0	88.0
2	**Shale** (as above in Unit 4): interbedded with sandstone and purple, foliated siltstone	42.0	52.0
1	**Sandstone:** quartzitic; white; fine grained; massive; ripple marks; conglomerate and maroon sandstone in scree; some dolomite cement.	10.0	10.0

Unit 1 is underlain by an estimated 300 m of sandstone, siltstone, and shale that were not examined in detail; base of succession is formed by Crescent Glacier Fault.

SECTION L2

This section is situated near Clements Markham River (Field Station 29). The section was measured and described by R. Gardiner; his field notes were edited and summarized by Ulrich Mayr.

Overlying beds not exposed.

Otto Fiord Formation
(Upper Carboniferous)

Unit	Lithology	Thickness (m)	
		Unit	Total from base
16	**Anhydrite** and **gypsum**	67.5	670.5
15	**Sandstone:** light grey; fine grained in lower part, coarse grained in upper part; thin bedded, interbeds of black, silty, argillaceous dolomite; unit poorly exposed in lower part	33.0	603.0
14	**Anhydrite** and **gypsum**	12.0	570.0

Borup Fiord Formation
(Upper Carboniferous)

Contact not exposed

Unit	Lithology	Thickness (m)	
		Unit	Total from base
13	**Dolomite:** silty and sandy; very fine crystalline; very dark grey; unit poorly exposed; interbeds of medium grained, light grey sandstone in middle part	45.0	558.0
12	**Siltstone** and very fine grained sandstone; medium grey; thin bedded; interbedded with black argillaceous dolomite and black, dolomitic shale; mudcracks in lower part of unit (GSC loc. C-70306, Mineralogical analysis, see Appendix 3)	127.5	513.0

Unit	Lithology	Thickness (m)	
		Unit	Total from base
11	**Sandstone:** light grey; medium and fine grained	16.5	385.5
10	Covered interval	25.5	369.0
9	**Sandstone:** light grey; fine grained; interbeds of green and red shale	48.0	343.5
8	Covered interval: red shale(?)	27.0	295.5
7	**Limestone:** very sandy; green-grey	16.5	268.5
6	**Siltstone:** sandy and dolomitic; green with minor red interbeds	70.0	252.0
5	**Shale:** slightly calcareous; maroon; rare interbeds of shaly limestone (Mineralogical analysis, GSC loc. C-70197, see Appendix 4)	77.0	182.0
4	Covered interval	22.0	105.0
3	**Shale:** green; platy cleavage; some interbeds of fine grained maroon sandstone	47.0	83.0
2	**Sandstone:** calcareous; light grey; fine grained, thin bedded; interbedded with dark grey shale	21.0	36.0
1	**Dolomite:** argillaceous and silty; dark grey; very fine crystalline; thin bedded; argillaceous limestone at base of unit.	15.0	15.0

Underlying beds not exposed.

SECTION M

This section is situated near a lake at the head of Clements Markham Inlet (Field Station 36). The section was measured and described by R. Gardiner and D. Jones. Field notes were edited by Ulrich Mayr.

Nansen Formation
(Upper Carboniferous)

Top of outcrop

Unit	Lithology	Thickness (m)	
		Unit	Total from base
16	**Limestone:** white; coarse crystalline; (?)recrystallized	3.0	238.5
15	**Dolomite:** dark grey; fine crystalline; massive	19.5	235.5
14	**Dolomite:** cherty; very dark grey; fine crystalline; bryozoan and crinoid fragments; weathered vugs	30.0	216.0
13	**Dolomite:** very cherty; dark grey; fine crystalline	30.0	186.0
12	**Limestone**: as in Unit 10 below, abundant crinoid and brachiopod fragments; unit contains 4.5 m thick diabase sill	31.5	156.0
11	**Limestone**: dolomitic; light grey-brown; medium bedded; skeletal packstone (GSC loc. C-70066, Late Carboniferous, late Moscovian, see Appendix 3b)	21.0	124.5
10	**Limestone:** massive; skeletal grainstone (GSC loc. C-70060, Late Carboniferous, early Moscovian, see Appendix 3b)	6.0	103.5
9	**Dolomite:** hard and cherty; medium crystalline; very fossiliferous	28.5	97.5
8	**Limestone:** dolomitic; light grey; very thick bedded; fossiliferous	6.0	69.0
7	**Limestone:** dolomitic; light grey; very thick bedded; interbed of conglomerate, chert nodules	31.5	63.0
6	**Conglomerate:** calcareous; black and red shale clasts, quartz pebbles	3.0	31.5
5	**Limestone:** dolomitic; light grey; massive	5.1	28.5
4	**Conglomerate**: maroon; chert pebbles	6.9	23.4
3	**Limestone:** dolomitic; light grey; massive	7.0	19.5
2	Covered interval	8.7	12.5
1	**Sandstone:** maroon; fine grained; basal conglomerate.	3.8	3.8

Section underlain by lower Paleozoic basement rocks.

SECTION N

This section is situated southwest of the head of Markham Fiord. The section consists of a large number of separate field stations, examined along 5 km (traverse) between Field Stations 29 and 32. Thicknesses between field stations were estimated graphically from elevation and dip measurements. The section was measured and described by Ulrich Mayr.

Section terminated by reverse fault.

Degerböls Formation
(Permian)

Unit	Lithology	Thickness (m)	
		Unit	Total from base
59	Covered: probably chert and limestone as in Unit 58	60.0	2262.0
58	**Chert:** very dark grey; thin bedded, nodular; interbeds of medium grey and slightly silty, argillaceous, lime mudstone	15.0	2202.0
57	Covered	75.0	2187.0
56	**Limestone:** very light grey-brown; thick bedded; coarse to very coarse grained skeletal grainstone; very abundant large brachiopods (GSC loc. C-70008, Late Permian, early Wordian, see Appendix 3b)	10.0	2112.0
55	**Chert:** light grey-yellow; thin bedded; spiculite; rare *Zoophycos* sp.; unit weathers recessive.	75.0	2102.0

Tanquary Formation
(Permian)

Contact sharp, disconformable

Unit	Lithology	Thickness (m)	
		Unit	Total from base
54	**Limestone:** cherty; medium to light grey-brown; coarse to very coarse grained, skeletal floatstone; thin bedded in lower part, thick bedded in upper part; black chert nodules and minor black shale partings; very fossiliferous, *Zoophycos* sp.	95.0	2027.0

Unit	Lithology	Thickness (m) Unit	Thickness (m) Total from base
53	**Limestone:** siliceous; medium grey; medium bedded; chert nodules; mottled with dolomite; skeletal grainstone; foraminifers (GSC loc. C-70004, Early Permian, Leonardian, see Appendix 3b)	365.0	1932.0
52	**Limestone:** silty and slightly argillaceous; dark grey; thin bedded; chert nodules; lime mudstone	35.0	1567.0
51	**Limestone:** medium to light grey; coarse grained skeletal packstone; thick bedded; minor faults in section; corals in scree (GSC loc. C-70002, Early Permian, Asselian or Sakmarian, see Appendix 3b).	60.0	1532.0
	Mount Bayley Formation (Permian, Upper Carboniferous)		
	Contact probably conformable		
50	**Anhydrite:** inaccessible	60.0	1472.0
	Major fault, displacement not known		
49	**Anhydrite** and **gypsum:** thick bedded with lamination; interbedded with **limestone:** very dark grey; lime mudstone. Unit poorly exposed and folded	(?)230.0	1412.0
48	**Breccia:** grey; massive; very poorly sorted, angular to subrounded limestone pebbles, 5 cm maximum pebble diameter; poorly consolidated; abundant crinoid fragments in pebbles or as clasts of breccia; (?)interbedded with **limestone:** medium grey; lime mudstone and crinoidal wackestone, massive. Unit very poorly exposed, contains several sills.	140.0	1182.0
	Canyon Fiord Formation(?)		
	Contact faulted		
47	**Sandstone:** yellow; medium to coarse grained; interbedded with green-grey; slightly calcareous siltstone	60.0	1042.0
46	Sill	(?)50.0	982.0
45	**Sandstone:** conglomeratic; yellow; rare limestone interbeds; *Zoophycos* sp.; unit folded	(?)150.0	932.0
44	**Siltstone:** slightly sandy and calcareous; medium green-grey; thin bedded; interbedded with dark grey; very calcareous shale	9.0	782.0
43	**Sandstone:** calcareous; yellow; medium grained	8.0	773.0
42	**Limestone:** sandy; very light grey; medium bedded; lime mudstone; interbedded with medium grey skeletal wackestone; crinoid fragments and small brachiopods	9.0	765.0
41	**Sandstone:** very calcareous; light yellow; fine grained; thin bedded; well sorted and rounded; interbedded with calcareous siltstone and thin bedded, nodular and sandy limestone; very sharp lower contact.	100.0	756.0
	Canyon Fiord Formation (Upper Carboniferous)		
40	(Felsenmeer) **Sandstone:** impure; maroon; medium grained; (?)thin bedded	91.0	656.0
39	**Sandstone:** maroon; medium and fine grained	9.2	565.0
38	**Sandstone:** conglomeratic; light maroon; very coarse grained; thick bedded; in upper part coarse grained, laminated; fractures platy	3.1	555.8
37	**Sandstone:** conglomeratic; light pink-grey; very coarse grained; large trough crossbeds	4.5	552.7
36	**Sandstone:** micaceous; maroon; fine grained; thick bedded; litharenite; poorly sorted	9.2	548.2
35	**Sandstone:** pure; light yellow-brown; medium grained; medium bedded; well sorted and rounded	1.5	539.0
34	**Sandstone:** conglomeratic; light grey-brown; very coarse grained; medium to thick bedded; pink chert pebbles	1.5	537.5
33	Covered	43.0	536.0
32	**Conglomerate:** maroon; 2 cm maximum pebble diameter; thin bedded; very coarse grained matrix	3.1	493.0
31	**Sandstone:** maroon; medium grained; thin bedded	6.2	489.9
30	**Conglomerate:** brown-maroon; 10 cm maximum cobble size; medium to thick bedded, vague crossbeds; pebbles of varicoloured chert, carbonate, green and red quartzite; mean pebble size alternates from bed to bed; upper boundary sharp	6.2	483.7
29	**Sandstone:** maroon; fine grained; thin bedded; abrupt upper contact	1.5	477.5
28	**Shale:** calcareous; maroon; variably silty; interbedded with maroon; medium grained sandstone; sublitharenite	66.0	476.0
27	**Sandstone:** maroon; coarse grained; thin bedded, tangential planar crossbeds	2.1	410.0
26	**Conglomerate:** maroon; 4 cm maximum pebble diameter; thick bedded, large tangential trough crossbeds	1.2	407.9
25	**Shale:** calcareous; light green; interbedded with very calcareous, maroon shale; interbedded with thin beds of medium green-grey, medium grained quartzite	10.5	406.7

Unit	Lithology	Thickness (m) Unit	Thickness (m) Total from base
24	Covered	15.2	396.2
23	**Sandstone:** micaceous; maroon; very fine grained; thin bedded	9.4	381.0
22	**Sandstone:** maroon; medium grained; thin bedded; in upper part very coarse grained and with floating pink chert pebbles	3.0	371.6
21	**Dolomite:** light grey; aphanocrystalline; thin bedded	1.5	368.6
20	**Shale:** maroon; resistant	6.1	367.1
19	(Felsenmeer) **Sandstone:** maroon; medium grained; medium bedded	19.0	361.0
18	**Sandstone:** conglomeratic; coarse grained; thin bedded	1.5	342.0
17	Covered	9.0	340.5
16	**Sandstone:** maroon; medium grained; trough crossbeds; conglomeratic zones	4.5	331.5
15	Covered	3.0	327.0
14	**Sandstone:** slightly conglomeratic; maroon; coarse grained; thin bedded	3.0	324.0
13	Felsenmeer: as in Unit 19	55.0	321.0
12	**Conglomerate:** light grey; 2 cm maximum pebble diameter; several zones with 4 cm maximum pebble diameter; white and pink chert	25.0	266.0
11	Covered	65.0	241.0
10	**Sandstone:** maroon; medium grained; thin to medium bedded; interbedded with **quartzite:** very light grey; medium grained; thick bedded	55.0	176.0
9	**Conglomerate:** maroon; 2 cm maximum pebble diameter; chert, subangular; sharp lower boundary.	6.0	121.0
	Undivided lower Paleozoic sequence		
	Contact unconformable		
8	**Siltstone:** sandy; olive-green	3.0	115.0
7	Covered	40.0	112.0
6	**Sandstone:** conglomeratic; brown	1.5	72.0
5	**Shale**	3.0	70.5
4	Covered	7.5	67.5
3	**Shale:** green; interbedded with laminae of medium grained sandstone	10.0	60.0
2	Covered	45.5	50.0
1	**Conglomerate:** green brown; 13 cm maximum pebble size; very thick bedded to massive; vague fining-upward cycles.	4.5	4.5

SECTION O

This section was measured in the cliffs on the west side of the middle part of Markham Fiord (Field Stations 51 and 52, Figure 21). The section was measured and described by Ulrich Mayr and D. Pulishy.

Unit	Lithology	Thickness (m) Unit	Thickness (m) Total from base
	Assistance Formation (Permian)		
	Top of outcrop		
48	**Sandstone:** grey-green; fine grained; thin to medium bedded	9.0	732.0
47	**Conglomerate:** brown	4.5	723.0
46	**Shale:** green	1.0	718.5
45	**Sandstone:** conglomeratic, coarse grained; medium bedded	1.5	717.5
44	**Sandstone:** maroon; medium grained; medium to thick bedded; interbedded with maroon shale and siltstone; in uppermost part bed of grey, conglomeratic sandstone	13.5	716.0
43	**Sandstone:** conglomeratic, coarse grained; abundant trough crossbeds; minor maroon siltstone interbeds	13.5	702.5
42	Unit of fining-upward cycles: 1 to 9 m thick; at base of cycles white chert conglomerate; unit overall maroon coloured	27.0	689.0
41	**Sandstone** (as below in Unit 10): coarsening-upward; in lower part interbedded with maroon siltstone	25.5	662.0
40	**Sandstone:** grey-green; very fine grained, coarsening upward; medium bedded with interval lamination; interbedded with shale	15.0	636.5
39	Covered	1.5	621.5
38	**Sandstone:** very slightly calcareous; green; very fine grained; thick bedded	3.5	620.0
37	**Shale:** green	12.0	616.5
36	Covered	7.5	604.5
35	**Siltstone:** siliceous; dark grey; medium bedded; shaly interbeds; grades into thin bedded, siliceous shale in upper part of unit	16.5	597.0
34	**Chert:** dark grey; medium bedded; sharp lower boundary; abundant brachiopods in upper part	6.5	580.5
33	**Siltstone:** calcareous; very dark grey; thick bedded; minor interbeds and partings of black shale; abundant brachiopods (GSC loc. C-99547, Permian, late Leonardian to early Wordian, see Appendix 3b)	6.0	574.0
32	Covered.	43.5	568.0

Unit	Lithology	Thickness (m) Unit	Total from base
	Belcher Channel Formation (Permian, Upper Carboniferous)		
	Contact sharp, disconformable		
31	**Chert:** medium grey; thick to very thick bedded	10.5	524.5
30	Unit not examined, in part covered, thickness estimated	239.5	514.0
29	**Limestone:** as in unit 27; skeletal fragments, corals	6.0	274.5
28	**Limestone:** dark grey; thick bedded; (?)skeletal grainstone; chert nodules	18.0	268.5
27	**Limestone:** argillaceous and silty; dark grey; thin bedded	7.5	250.5
26	Covered interval	10.5	243.0
25	**Shale:** calcareous and silty; grey-green	3.0	232.5
24	Covered interval: at 222 m a small outcrop of coated-grain grainstone	19.5	229.5
23	**Limestone:** silty and argillaceous; yellow; thin bedded; chert nodules; brachiopods; interbeds of limestone as in unit 22	13.5	210.0
22	**Limestone:** dark grey; medium to thick bedded; skeletal packstone and grainstone	18.0	196.5
21	**Limestone:** light grey; medium bedded; argillaceous in lower part, abundant chert nodules; skeletal wackestone and packstone	6.0	178.5
20	**Limestone:** medium grey; thick to very thick bedded; skeletal grainstone	23.5	172.5
19	**Limestone:** as in unit 17; poorly exposed	21.0	149.0
18	**Limestone:** medium grey; thick bedded; skeletal grainstone	1.0	128.0
17	**Limestone:** dark to medium grey; medium bedded; lime mudstone and skeletal wackestone	7.5	127.0
16	**Limestone:** light grey; very thick bedded; skeletal packstone	3.5	119.5
15	**Limestone:** dark grey; thin to medium bedded; interbedded with **dolomite:** silty; medium crystalline	1.5	116.0
14	**Limestone:** as in unit 6	6.0	114.5
13	**Sandstone:** calcareous; light grey; very coarse grained; medium bedded; skeletal fragments	1.0	108.5
12	**Limestone:** as below in unit 10	3.5	107.5
11	**Sandstone:** conglomeratic; light grey; medium to thick bedded; corals; very sharp upper and lower contacts	3.0	104.0
10	**Limestone:** argillaceous; medium grey; medium bedded	1.5	101.0
9	**Limestone:** light grey; thick bedded; packstone, some coated grains; solitary corals in upper part of unit	4.5	99.5
8	Covered interval	6.0	95.0
7	**Limestone:** medium grey; very thick bedded; skeletal wackestone; rare solitary corals	3.0	89.0
6	**Limestone:** very light grey; very thick bedded; skeletal grainstone	15.0	86.0
5	**Limestone:** as in unit 3	6.0	71.0
4	Sill: **diabase**	19.5	65.0
3	**Limestone:** very light grey; medium to coarse crystalline; corals	5.0	45.5
2	**Limestone:** medium grey; medium to thick bedded; zones with chert nodules; lime mudstone and skeletal wackestone; solitary corals common	19.5	40.5
1	**Limestone:** light grey; thick to very thick bedded; lime mudstone; rare crinoid and algal fragments.	21.0	21.0
	Underlying beds not exposed.		

SECTION P

This section is situated on the northwest side of the large U-shaped valley between the head of Tanquary Fiord and Yelverton Pass (Field Station 5). The section was measured and described by Ulrich Mayr and J. Calvert.

Nansen Formation
(Permian, Upper Carboniferous)

Section ends at top of mountain; end of section is approximately at stratigraphic level of base of a thick, regionally extensive sill.

Unit	Lithology	Thickness (m) Unit	Total from base
78	**Limestone:** light grey; medium calcarenite; thin bedded; pelletal grainstone, also some lumps and aggregate grains, skeletal fragments rare; solitary corals abundant; interbedded with fusulinid packstone	6.5	387.0
77	**Limestone:** light grey; calcirudite; thin bedded; fusulinid packstone and wackestone (GSC loc. C-45226, Late Carboniferous, late Gzhelian, see Appendix 3b)	8.5	380.5
76	Covered interval	2.0	372.0
75	**Limestone:** slightly argillaceous; medium grey; medium bedded; lime mudstone; fusulinids weathered out on bedding surfaces	1.0	370.0
74	Covered interval	2.0	369.0
73	**Limestone:** light grey; coarse calcarenite; thin bedded; fusulinid grainstone (GSC loc. C-45225, Late Carboniferous, early Gzhelian, see Appendix 3b)	1.0	367.0
72	Covered interval	7.0	366.0

Unit	Lithology	Thickness (m)	
		Unit	Total from base
71	**Limestone:** light grey; medium calcarenite; massive; skeletal wackestone and packstone with fragments of macrofossils and coralline algae, and pelletoids; grading to lime mudstone in upper part of unit	3.5	359.0
70	**Limestone:** siliceous and dolomitic; light grey; massive, irregular wavy lamination; lime mudstone	1.5	355.5
69	Covered interval	8.0	354.0
68	**Limestone:** light grey; thin bedded; lime mudstone	1.5	346.0
67	**Dolomite:** siliceous, light grey; dolosiltite; thin bedded; chert nodules; large solitary corals	2.5	344.5
66	**Limestone:** slightly silty; light grey; very fine calcarenite; thin to thick bedded; chert nodules; rare very large solitary corals	3.0	342.0
65	**Limestone:** light grey; massive; lime mudstone with floating fine skeletal fragments; irregular laminae and lenses of dolomite	3.0	339.0
64	Covered interval	15.0	336.0
63	**Limestone:** light grey; calcarenite; massive; skeletal grainstone; scattered solitary corals	5.0	321.0
62	**Limestone:** light grey; medium calcarenite; thin bedded	0.5	316.0
61	Covered interval	2.0	315.5
60	**Limestone:** light grey; fine calcarenite; massive; pelletoidal-skeletal grainstone; chert nodules	2.5	313.5
59	Covered interval	7.5	311.0
58	**Limestone:** light grey; medium calcarenite; thick bedded; skeletal grainstone	1.5	303.5
57	Covered interval	2.0	302.0
56	**Limestone:** light grey; massive; lime mudstone	5.5	300.0
55	**Limestone:** light grey; medium calcarenite; thick bedded; skeletal grainstone with minor ooids; abundant fusulinids	3.5	294.5
54	Covered interval	3.0	291.0
53	**Limestone:** light grey; fine calcarenite; thick bedded, fine sandy and silty laminae; pelletoidal grainstone, 10% skeletal clasts	2.0	288.0
52	**Limestone:** light grey; medium calcarenite; thick bedded; skeletal grainstone; 6 cm thick chert bed at base of unit	1.5	286.0
51	**Dolomite:** slightly calcareous; maroon; dolosiltite; thin bedded; corals; uppermost 1 m of unit consists of green shale; very sharp upper contact	6.5	284.5
50	**Limestone:** light grey; fine calcarenite; thick bedded; skeletal-pelletoidal grainstone; scattered large solitary corals	2.0	278.0
49	**Sandstone:** slightly calcareous; maroon; very fine grained; thin bedded; laminated argillaceous zone	0.5	276.0
48	**Limestone:** light grey; medium calcarenite; massive; skeletal grainstone	2.5	275.5
47	**Dolomite:** calcareous and argillaceous; maroon; dolosiltite; thin bedded; brachiopods	6.0	273.0
46	**Limestone:** sandy; light grey; fine calcarenite; massive, some domal bedding planes and thin crossbeds in lower part of unit; skeletal grainstone; brachiopods and solitary corals	7.5	267.0
45	Covered interval	3.5	259.5
44	**Limestone:** light grey; coarse calcarenite with zones of calcirudite; massive; skeletal grainstone, chert pebbles	7.5	256.0
43	**Siltstone:** calcareous; light grey-green; laminated to thin bedded	5.5	248.5
42	**Limestone:** light grey-yellow; medium calcarenite; thick bedded; skeletal packstone and grainstone; crinoid and brachiopod fragments	4.5	243.0
41	**Limestone**: as below, but yellow, turning maroon in upper part of unit	1.5	238.5
40	**Limestone:** slightly silty; light green; medium calcarenite; abundant fusulinids; maroon with chert nodules and bed in upper part	3.0	237.0
39	**Limestone:** silty and argillaceous; medium green; abundant fusulinids and corals	0.5	234.0
38	**Limestone:** sandy; light grey; coarse calcarenite; thick bedded; skeletal grainstone; >25% coralline algae fragments; colonial corals	1.0	233.5
37	Covered interval	2.0	232.5
36	**Limestone:** silty and sandy; light green-grey; lime mudstone to skeletal wackestone; rare brachiopods, crinoids common	1.5	230.5
35	Covered interval	3.5	229.0
34	**Limestone:** light grey; coarse calcarenite; massive; skeletal grainstone; fusulinids	5.0	225.5
33	Covered interval: at 200 m a bank of dolomite: calcareous, sandy; dolarenite	36.5	220.5
32	**Siltstone:** light green-grey; thin bedded; zone of chert-pebble conglomerate	4.5	184.0
31	**Limestone:** sandy; light grey; fine calcarenite; massive; skeletal grainstone	2.0	179.5

Unit	Lithology	Thickness (m)	
		Unit	Total from base
30	**Sandstone:** dolomitic; light grey; coarse grained; medium to thick bedded; zones and channels of pebble and cobble conglomerate; grading upward to **dolosiltite:** massive, with chert nodules. Uppermost 1 m of unit is discontinous limestone: fine calcarenite; sandy, pelletoidal packstone	17.0	177.5
29	Covered interval: probably mostly shale and fine grained calcareous sandstone	43.5	160.5
28	**Shale:** very dark grey; poorly exposed	1.0	117.0
27	**Siltstone:** calcareous; medium grey-green; laminated or thin bedded, some thick beds, crossbedding; interbedded with thin bedded limestone	3.5	116.0
26	**Sill:** diabase	5.0	112.5
25	Covered interval	5.5	107.5
24	**Sill:** diabase	3.0	102.0
23	Covered interval	11.0	99.0
22	**Sandstone:** medium grained; thin bedded; quartzarenite; some burrows; weathers with red hue	2.0	88.0
21	**Sandstone:** light grey; medium grained; thin bedded; poorly fossiliferous	0.5	86.0
20	**Limestone:** sandy; light grey; fine calcarenite; thick bedded; skeletal grainstone; grading upward into calcisiltite and lime mudstone	11.2	85.5
19	**Limestone:** light grey; medium calcarenite; massive; grainstone, mostly micritized grains	7.3	74.3
18	**Limestone:** light grey; coarse calcarenite to calcirudite; thick bedded; skeletal grainstone, mostly coralline algae clasts, zones of abundant corals; thin interbed of sandy calcisiltite	2.5	67.0
17	**Limestone:** light grey; medium calcarenite to calcirudite; thick bedded	5.0	64.5
16	**Limestone:** silty; light green; thick bedded; lime mudstone	1.0	59.5
15	**Limestone:** light grey; calcirudite; massive	3.0	58.5
14	**Limestone:** purple; medium calcarenite; thin to medium bedded; skeletal grainstone	1.5	55.5
13	**Shale:** calcareous; purple; abundant skeletal fragments; rare interbeds of argillaceous limestone (GSC loc. C-45191, Late Carboniferous, late Moscovian, see Appendix 3b)	1.0	54.0
12	**Limestone:** light grey; coarse calcarenite; massive; chert nodules; crinoidal grainstone	6.0	53.0
11	**Limestone:** light grey; coarse calcarenite to calcirudite; medium bedded; skeletal grainstone; interbeds of green, calcareous shale	2.0	47.0
10	Covered interval	10.0	45.0
9	**Limestone:** sandy, silty, dolomitic; light grey; medium calcarenite to calcirudite; medium to thick bedded; skeletal grainstone, interbedded with chert-pebble conglomerate	5.0	35.0
8	**Conglomerate:** very coarse chert pebbles; interbedded with very coarse grained, medium bedded sandstone	3.0	30.0
7	**Conglomerate:** in part breccia, very coarse pebbles; very coarse grained sand matrix, light green and black chert pebbles; interbedded with very fine grained pink sandstone	3.0	27.0
6	**Limestone:** sandy and conglomeratic, light pink-grey; medium calcarenite; thin to medium bedded; crinoidal grainstone; laminae of sandy dolosiltite	1.5	24.0
5	**Conglomerate:** coarse pebbles; medium bedded, indistinct crossbedding, imbricated pebbles; conglomerate units grade upward into calcareous, medium grained sandstone	0.5	22.5
4	**Siltstone:** calcareous, cherty; light grey; thin bedded; interbedded with silty lime mudstone; solitary corals; very coarse pebble conglomerate at base of unit	4.0	22.0
3	**Sandstone:** conglomeratic; light pink; very fine grained; thin bedded; laminae of chert after limestone and laminae of dolomite	1.5	18.0
2	Covered interval	15.0	16.5
1	**Breccia:** large cobbles; cobbles of chert and fine grained sandstone; interbedded with conglomeratic, medium grained sandstone.	1.5	1.5

Section underlain by lower Paleozoic basement rocks.

APPENDIX 3

PALEONTOLOGY

A. GSC location numbers (by formations)

Formation	Age	Section or Field Station	GSC loc. no.
Okse Bay	Devonian, Frasnian(?)	Section A	C-45307
	Middle or Late Devonian	Field Station 34	C-70282
	Middle or Late Devonian	Field Station 35	C-70283
Emma Fiord	Early Carboniferous, late Viséan or early Namurian	Section B	C-99616
Canyon Fiord	Late Carboniferous, Moscovian	Field Station 17	C-69854
Belcher Channel	Late Carboniferous, late Moscovian	Field Station 1	C-45119
	Late Carboniferous, early Gzhelian	Field Station 2	C-45135
	Early Permian, early Asselian	Field Station 2	C-45153
	Early Permian, early Sakmarian	Field Station 3	C-45499
	Early Permian, Asselian	Section D	C-69867
	Early Permian, Asselian	Section D	C-69868
	Early Permian, Asselian	Section D	C-69874
	Early Permian, late Asselian	Section D	C-69875
	Early Permian, early Sakmarian	Section D	C-69877
	Early Permian, early Sakmarian	Section D	C-69878
	Early Permian	Section D	C-69881
	Early Permian, Sakmarian	Section D	C-69882
	Early Permian	Section D	C-69883
	Early Permian, Sakmarian	Section D	C-69884
	Early Permian, early Artinskian(?)	Section D	C-69885
	Early Permian, Artinskian(?)	Section D	C-69894
	Early Permian	Section I	C-83452
	Early Permian, Asselian(?)	Section I	C-83463
	Early Permian, early Asselian(?)	Section I	C-83464
Antoinette	Late Carboniferous, late Moscovian	Section K	C-70316
Mount Bayley	Late Carboniferous, late Moscovian	Section K	C-70258
Tanquary	Early Permian, Asselian or Sakmarian	Section N	C-70002
	Early Permian, Leonardian	Section N	C-70004
Borup Fiord	No fossils of biostratigraphic value recovered		
Nansen	Late Carboniferous, late Moscovian	Section P	C-45191
	Late Carboniferous, Gzhelian	Section P	C-45225
	Late Carboniferous, late Gzhelian	Section P	C-45226
	Late Carboniferous, Bashkirian	Section E3	C-45383
	Permian, late Leonardian to early Wordian	Field Station 10	C-45391
	Late Carboniferous, middle(?) Bashkirian	Section E3	C-45421
	Late Carboniferous, Moscovian	Field Station 13	C-45457
	Late Carboniferous, Moscovian	Field Station 15	C-45471
	Late Carboniferous, Moscovian	Field Station 15	C-45476
	Late Carboniferous, middle Gzhelian	Field Station 15	C-45478
	Late Carboniferous, early Moscovian	Section M	C-70060
	Late Carboniferous, late Moscovian	Section M	C-70066
	Early Carboniferous, late Viséan or early Namurian	Section G	C-83322
	Late Carboniferous	Section G	C-83334
	Late Carboniferous, Moscovian	Section G	C-83339
	Late Carboniferous	Section G	C-83340
	Late Carboniferous, late Moscovian(?)	Section G	C-83345
Otto Fiord	No fossils recovered		

Formation	Age	Section or Field Station	GSC loc. no.
Hare Fiord	Late Carboniferous, Moscovian	Field Station 12	C-45449
	Late Carboniferous, Moscovian	Field Station 28	C-69969
	Late Carboniferous, middle Moscovian	Field Station 28	C-83359
	Late Carboniferous, Moscovian	Section F1	C-83369
Sabine Bay	Early Permian, Artinskian to Roadian	Field Station 4	C-45170
Assistance	Permian, late Leonardian to early Wordian	Field Station 10	C-43494
	Permian, late Leonardian to early Wordian	Section E1	C-45466
	Permian, Leonardian	Section D	C-69897
	Early Permian, Roadian(?)	Section D	C-82539
	Early Permian, Roadian(?)	Section D	C-82555
	Permian, Leonardian to Wordian	Section I	C-83473
	Permian, Leonardian to Wordian	Section O	C-99547
Trold Fiord	Late Permian, Wordian	Locality B of Miall (1979)	C-68635
	Late Permian, Wordian	Locality B of Miall (1979)	C-68637
	Late Permian, Wordian	Section D	C-82567
Degerböls	Permian, late Leonardian to early Wordian	Section E1	C-45469
	Late Permian, early Wordian	Section N	C-70008
	Late Permian, (?)Wordian	Field Station 53	C-99579

B. Fossil identifications

by

E.W. Bamber, M.S. Barss, A.C. Higgins, Z. Liao, B.L. Mamet,
D.C. McGregor, C.A. Ross, J. Utting, and B.R. Wardlaw

C.A. Ross, 1977

Belcher Channel Formation, Field Station 1, GSC loc. C-45119, 45.5 m above base of formation

Fusulinella eopulchra Rauzer-Chernousova
Ozawainella cf. *O. angulata* Colani
Wedekindellina cf. *W. dutkevichi* Rauzer-Chernousova and Belyaev
Wedekindellina sp.
other smaller Foraminifera

Age: Late Carboniferous, late Moscovian (Myachkovian)

Field Station 2, GSC loc. C-45135, 216 m below top of formation, probably in basal part of formation

Pseudofusulinella sp.
Schubertella sp.
Quasifusulina cf. *Q. longissima* Moeller
Triticites cf. *T. unbonoplicatus* Rauzer-Chernousova and Belyaev

Age: Late Carboniferous, early Gzhelian

Field Station 2, GSC loc. C-45153, 168 m below top of formation, lower part of formation

Pseudofusulinella cf. *P. annae* (Grozdilova)
Pseudofusulina sophiae Grozdilova

Age: Early Permian, early Asselian

J. Utting, 1985

Sabine Bay Formation, Field Station 4, GSC loc. C-45170, upper part of formation

Alisporites sp.
Apiculatisporis spp.
Biannulatisphaerites sp.; common
Botryococcus sp.
Cycadopites sp.
Diatomozonotriletes sp.
Dictyotriletes sp.
Klausipollenites aequus (Wilson) Clapham
K. schaubergeri (Potonié and Klaus) Jansonius
Kraeuselisporites sp.
Leiotriletes nigrans Naumova
Leiotriletes sp.
Lophotriletes spp.
Neoraistrickia sp.
Nevesisporites sp.
Protohaploxypinus sp.
Raistrickia sp.
Verrucosisporites sp.
Vittatina striata Luber

Comments and age: The assemblage is unusual in that it differs in detail from any so far seen in the Canadian Arctic Archipelago, although it contains many forms similar to those known from the Sabine Bay and Assistance formations of Melville Island, which are believed from faunal data to be of Artinskian age (Utting, 1985). Species from these units are currently in the process of being described, and thus species names are not yet available for many of the forms listed above. The assemblage differs from those known so far from the western Arctic Archipelago, by the relative scarcity of striate disaccate pollen, and by the common occurrence of *Biannulatisphaerites* sp. The assemblage differs from those of Sakmarian age (from the lower Belcher Channel Formation of the western Arctic Archipelago), and from the upper part of the Belcher Channel Formation in the BP et al. Graham C-52 well (306.2-306.7 m), in that the Sakmarian assemblages are dominated by striate disaccate pollen (*Protohaploxypinus* spp.) and polyplicate pollen (*Vittatina* spp.). The Trold Fiord Formation, which overlies the Assistance Formation, and which is believed to range in age from Wordian to Capitanian, contains assemblages not dramatically different qualitatively from those of the Artinskian, although there is generally a greater variety of trilete spores than found in the present sample. Thus, it is probable that the sample is post-Sakmarian, but pre-Wordian in age; that is, Artinskian to Roadian.

Environment of deposition: the freshwater algal genus *Botryococcus* sp. is common in the sample and probably indicates a nonmarine environment of deposition. Neither typical marine acritarch genera such as *Veryhachium* and *Michrystridium* nor scolecodonts (jaws of annelid worms) were seen.

C.A. Ross, 1977

Nansen Formation, Section P, Unit 13, GSC loc. C-45191, 26.5 m from base of formation

Fusulinella pulchra Rauzer-Chernousova and Belyaev
Fusulina cf. *F. consobrina* Safonova
Ozawainella cf. *O. angulata* Coleni
Wedekindellina cf. *W. dutkevichi* Rauzer-Chernousova and Belyaev
other smaller Foraminifera

Age: Late Carboniferous, late Moscovian (Myachkovian)

Section P, Unit 73, GSC loc. C-45225, 331.5 m above base of formation

Pseudofusulina (Rugosofusulina) cf. *P. (R.) prisca* (Ehrenberg)
other smaller Foraminifera

Age: Late Carboniferous, Gzhelian (early part)

Section P, Unit 77, GSC loc. C-45226, 349.5 m above base of formation

Pseudofusulina (Daixina) vetustus (Schellwien)
Pseudofusulinella sp.

Age: Late Carboniferous, late Gzhelian

M.S. Barss, 1975

Okse Bay Formation, Section A, Unit 73 (Lower member), GSC loc. C-45307, 28 m below top of member

Ancyrospora cf. *A. ampulla* Owens
Ancyrospora spp.
Apiculiretusispora sp.
Apiculatisporis sp.
cf. *Archeoperisaccus oblongus* Owens

Brochotriletes sp.
Dictyotriletes sp.
Grandispora cf. *G. douglastownense* McGregor
Grandispora sp.
Hystricosporites sp.
Punctatisporites sp.
Retusotriletes spp.
Rhabdosporites langi (Eisenack) Richardson
Samarisporites sp.
Spinozonotriletes sp.
Verrucosisporites sp.

Comments and age: The spores are poor to good in preservation and required prolonged oxidation to make them transparent and suitable for study. The assemblage is Devonian (probably Frasnian) in age.

B.L. Mamet, 1986

Nansen Formation, Section E3, Unit 124, GSC loc. C-45383, basal part of lower member

Bradyina sp.
Climacammina sp.
Endothyra sp.
Pseudostaffella sp.
Pseudoendothyra sp.
Palaeotextularia sp.
Eostaffella sp.

Comments and age: The first occurrence of *Pseudostaffella* is Bashkirian with *Pseudostaffella antiqua* often used by the Russians in the central part of the Tethys to underline the base of the Bashkirian. Thus, this is a minimal age.

Z. Liao, 1983

Nansen Formation, Field Station 10, GSC loc. C-45391, top of formation

Horridonia scoresbyensis Dunbar
Liosotella pseudohorrida (Wiman)
Thamnosia proxima sp. nov.
Neospirifer groenwallis Dunbar
N. fasciger
Spiriferella draschei (Toula)
Paeckelmannella magna sp. nov.
?*Megousia* sp.

Comments: as for C-45394.

Assistance Formation, Field Station 10, GSC loc. C-45394, basal part of formation

Derbyia media sp. nov.
?*Derbyia* sp.
Quadrochonetes sp.
Megousia sp.
Waagenoconcha sp.
Cancrinella sp.
Yakovlevia duplex (Wiman)
Wellerella sp.
Crurithyris sp.
Spiriferella sp.
Squamularia sp.
Paeckelmannella expansa (Tschernyschew)

Comments and age: This locality contains abundant brachiopod specimens. The fauna indicates a late Leonardian to early Wordian age, and is equivalent to the faunas of the upper Assistance Formation or lower Trold Fiord Formation, but has many genera and species characteristic of the Trold Fiord fauna in central Ellesmere Island.

C.A. Ross, 1977

Nansen Formation, Section E3, Unit 186, GSC loc. C-45421, 213 m above base of formation, lower member (C.A. Ross, 1977)

Pseudostaffela antiqua (Dutkevitch)
Eostaffella cf. *E. pseudostruvei* Rauzer-Chernousova
Endothyra sp.
Pseudoendothyra cf. *P. pritonensis* (Grozdilova and Lebedeva)
Archaediscus cf. *A. nina* Grozdilova and Lebedeva
other smaller Foraminifera

Age: Late Carboniferous, Bashkirian (middle?)

B.L. Mamet, 1985

Hare Fiord Formation, Field Station 12, GSC loc. C-45449, basal part of formation, basal beds of a reef

Ammovertella sp.
Apterrinellids
Monotaxinoides sp.
Tubiphytes sp.
Trepeilopsis sp.
Tuberitina sp.
Volvotextularia sp.

Comments: A 'waulsortian-type' reef facies. Quite common in the Moscovian, in particular the Tellevak Limestone. It is undiagnostic Moscovian or slightly younger.

C.A. Ross, 1983

Nansen Formation, Field Station 13, GSC loc. C-45457, top of formation, overlain by Triassic units

Fusulinella cf. *F. pulchra* Rauser-Chernousova
Bradyina sp. (very large)

Age: Late Carboniferous, Moscovian (Myachkovian)

Z. Liao, 1983

(?)Assistance Formation, Section E1, Unit 18, GSC loc. C-45466, base of formation

Liosotella pseudohorrida (Wiman)
Horridonia sp.
Bathymyonia sp.

Comments: as for C-45394

(?)Degerböls Formation, Section E1, Unit 19, GSC loc. C-45469, estimated 100 m above base of formation

Megousia sp.
Horridonia cf. *granulifera* (Toula)
Spiriferella sp.

Comments: as for C-45391

C.A. Ross, 1977

Nansen Formation, Field Station 15, GSC loc. C-45471, 1.5 m above base of formation

Pseudoendothyra moelleri (Ozawa)
Pseudoendothyra umbonata (Rauzer-Chernousova)
Pseudoendothyra pseudospherica (Dutkevitch)
Schubertella cf. *S. acuta* Rauzer-Chernousova
other smaller Foraminifera

Age: Late Carboniferous, early Moscovian, (Kashirian)

Field Station 15, GSC loc. C-45476, 102.5 m above base of formation

Fusulinella cf. *F. pulchra* Rauzer-Chernousova and Belyaev
Schubertella sp.
Fusulinella sp.
a few other smaller Foraminifera

Age: Late Carboniferous, Moscovian, (probably Myachkovian)

Field Station 15, GSC loc. C-45478, top of formation

Triticites cf. *T. paucus* Grozdilova
other smaller Foraminifera

Age: Late Carboniferous, middle Gzhelian

Belcher Channel Formation, Field Station 3, GSC loc. C-45499, 14.5 m below top of formation

Eoparafusulina cf. *E. paralinearis* Thorsteinsson

Age: Early Permian, early Sakmarian (Tastubian)

B.R. Wardlaw, 1978

Trold Fiord Formation, Locality B (Miall, 1979), GSC loc. C-68635, 30 m above base of formation

Arctitreta cf. *A. kempei* (Andersson)
Chonetina?
Kuvelousia cf. *K. sphiva* Waterhouse
Neospirifer cf. *N. striatoparadoxus* (Toula)
Sowerbina maynci Dunbar
Spiriferella keilhavii (Buch)
Stenocisma sp.
Thuleproductus sp.
Waagenoconcha cf. *W. irginae* (Struckenberg)
Yakovlevia cf. *Y. mammata* (Keyserling)
Pectenoid clam

Comments and age: This fauna is Guadalupian, Wordian in age, and probably equivalent to the faunas of the Trold Fiord Formation.

Locality B (Miall, 1979), GSC loc. C-68637, 108 m above base of formation

Horridonia cf. *H. bullocki* Nelson and Johnson
Neophricodothyris sp.
Spiriferella keilhavii (Buch)
Spiriferella sp.
Thamnosia sp.
Timaniella sp.
Waagenoconcha?
Yakovlevia cf. *Y. greenlandica* (Dunbar)

Comments and age: This fauna is Guadalupian, Wordian in age, and probably equivalent to the faunas of the Trold Fiord Formation. This fauna shows stronger affinities to the Assistance Formation than C-68635.

C.A. Ross, 1978

Canyon Fiord Formation, Field Station 17, GSC loc. C-69854 lower or middle part of formation

Millerella sp.
Pseudostaffella cf. *P. umbilicata* (Putrja and Leont.)
Ozawainella cf. *O. vozhgalia* Saf.

Age: Late Carboniferous, Moscovian (Podolian, possibly as old as Kashirian)

Belcher Channel Formation, Section D, Unit 1, GSC loc. C-69867, 575.1 m below top of formation

Schubertella sp.
Schwagerina cf. *S. limata* (Grozdilova)
S. cf. *S. fluxa* (Grozdilova)

Age: Early Permian, Asselian

Section D, Unit 2, GSC loc. C-69868, 553.8 m below top of formation

Pseudofusulinella sp.
Schwagerina sp.

Age: Early Permian, Asselian

Section D, Unit 9, GSC loc. C-69874, 514.4 m below top of formation

Pseudofusulinella sp.
Schwagerina cf. *S. limata* (Grozdilova)
S. cf. *S. nenetskensis* (Grozdilova)

Age: Early Permian, Asselian

Section D, Unit 11, GSC loc. C-69875, 505.6 m below top of formation

Schwagerina cf. *S. agnata* (Grozdilova)

Age: Early Permian, late Asselian

Section D, Unit 12, GSC loc. C-69877, 482.1 m below top of formation

Schwagerina cf. *S. uralica* (Krotow)

Age: Early Permian, early Sakmarian

Section D, Unit 14, GSC loc. C-69878, 429.8 m below top of formation

Schwagerina cf. *S. uralica* (Krotow)
Schwagerina spp.

Age: Early Permian, early Sakmarian

E.W. Bamber, 1978

Belcher Channel Formation, Section D, Unit 19, GSC loc. C-69881, 368.8 m below top of formation

Protowentzellela sp.

Age: Early Permian

C.A. Ross, 1978

Belcher Channel Formation, Section D, Unit 19, GSC loc. C-69882, 364.2 m below top of formation

Pseudofusulinella sp. ex gr. *P. sulaensis* (Grozdilova and Leb.)
Schwagerina cf. *S. paraverneulli* (Viss.)
Schwagerina sp.

Age: Early Permian, Sakmarian

Section D, Unit 22, GSC loc. C-69883, 275.7 m below top of formation

Eoparafusulina cf. *E. tschernyschewi* (Schellwien)
Schwagerina cf. *S. indigaensis* (Grozdilova and Leb.)
S. cf. *S. irregularis* (Grozdilova and Leb.)

Age: Early Permian, Sakmarian

Kleopatrina (Kleopatrina) sp.

Age: Early Permian

Section D, Unit 23, GSC loc. C-69884, 242.7 m below top of formation

Schwagerina cf. *S. irregularis* (Grozdilova and Leb.)
S. cf. *S. indigaensis* (Grozdilova and Leb.)

Age: Early Permian, Sakmarian

Section D, Unit 24, GSC loc. C-69885, 203.3 m below top of formation

Schwagerina cf. *S. paraverneulli* (Viss.)
S. cf. *S. indigaensis* (Grozdilova and Leb.)
Schwagerina hyperborea (Salter)
S. jenkinsi Thorsteinsson
Parafusulina belcheri Thorsteinsson

Age: Early Permian, probably early Artinskian

B.R. Wardlaw, 1978

Belcher Channel Formation, Section D, Unit 35, GSC loc. C-69894, top of formation

Kochiproductus sp.
Licharewia sp.
Lissochonetes cf. *L. superba* (Gobbett)
Rhynchopora sp.
Waagenoconcha?

Comments and age: This fauna is probably Artinskian, Aktastinian in age. It is probably equivalent to the faunas of the middle and upper parts of the Belcher Channel Formation.

Assistance Formation, Section D, Unit 39, GSC loc. C-69897, 158.9 m above base of formation

Neospirifer sp.
Spiriferella cf. *S. saranae* (de Verneuil)
Thamnosia sp.

Comments: This fauna is Artinskian, Leonardian in age.

B.L. Mamet, 1986

Hare Fiord Formation, Field Station 28, GSC. loc. C-69969, estimated 95 m above base of formation

Apterrinellids
Climacammina sp.
Deckerella sp.
Globivalvulina sp.
Glyphostomella sp.
Komia sp.
Komia abundans Korde
Neostaffella sp.
Profusulinella sp.
Tetrataxis sp.
Ungdarella sp.

Age: Late Carboniferous, mid-Moscovian or slightly younger

E.W. Bamber, 1978

Tanquary Formation, Section N, Unit 51, GSC loc. C-70002, talus, probably lower part of formation

Kleopatrina (*Porfirievella*) sp.

Age: Early Permian, probably Asselian or Sakmarian

C.A. Ross, 1983

Tanquary Formation, Section N, Unit 53, GSC loc. C-70004, estimated 400 m above base of formation

Boultonia sp.
Schwagerina cf. *S. jenkinsi* Thorsteinsson
Schwagerina sp.

Age: Early Permian, Leonardian

B.R. Wardlaw, 1981

Degerböls Formation, Section N, Unit 56, GSC loc. C-70008, estimated 85 m above base of formation

Bathymyonia sp.
Horridonia bullocki Nelson and Johnson
Liosotella cf. *L. pseudohorrida* (Wiman)
Neospirifer striato-paradoxus Toula
Spiriferella '*saranae*' of Harker
Yakovlevia greenlandica (Dunbar)

Comments: This fauna is early Wordian (earliest Gaudalupian) in age.

C.A. Ross, 1983

Nansen Formation, Section M, Unit 10, GSC loc. C-70060, 103.5 m above base of formation

Profusulinella ex gr. *P. parva* (Lee and Chen)

Age: Late Carboniferous, early Moscovian (probably Verean)

Section M, Unit 11, GSC loc. C-70066, 112.5 m above base of formation

Silicified: *Fusulinella*? cf. *F. eopulchra* (Rauser)

Age: Late Carboniferous, late Moscovian (possible as young as Myachkovian)

Mount Bayley Formation, Section K, Unit 77, GSC loc. C-70258, 506 m above base of formation

"Parastaffella" moelleri (Ozawa)
Fusulinella cf. *F. pulchra* Rauser-Chernousova

Age: Late Carboniferous, late Moscovian, (Myachkovian)

D.C. McGregor, 1978

Okse Bay Formation, Field Station 34, GSC loc. C-70282, Lower member, stratigraphic position in member not known

Comments and age: This sample is of Middle or Late Devonian age. The few spores that could be identified (*Hystricosporites* spp. and ?*Aneurospora* sp.) and the general appearance of the assemblage suggest late Givetian or Frasnian, but this conclusion should be regarded as tentative.

In addition to spores, there are fragments of plant conducting tissue, of no value for more refined age determination. No marine palynomorphs were seen.

The palynomorphs are highly carbonized, and commonly fragmentary.

Field Station 35, GSC loc. C-70283, Upper member, upper(?) part of member

Comments and age: Spores are abundant and varied in this sample, but so diagenetically altered that few identifications can be made. *Ancyrospora* spp. and *Hystricosporites* sp. are certainly present, and indicate Middle or Late Devonian age. *Cymbosporites, Aneurospora, Corystisporites*, and *Perotrilites* were identified tentatively. Late Givetian or Frasnian age is perhaps the more reasonable age assignment, but cannot be confirmed.

There is no evidence of any marine palynomorph component in the assemblage. Fragments of plant tracheids, produced by land plants, are abundant.

C.A. Ross, 1978

Antoinette Formation, Section K, Unit 26, GSC loc. C-70316, approximately 71 m above base of formation

Pseudostaffella cf. *P. paradoxa* (Dutk.)
Fusulinella cf. *F. eopulchra* Rauser-Chernoussova

Age: Late Carboniferous, late Moscovian (Myachkovian)

B.R. Wardlaw, 1981

Assistance Formation, Section D, Unit 38, GSC loc. C-82539, 105 m above base of formation

Cleiothyridina cf. *C. subexpansa* (Waagen) of Harker
Derbyia sp.
Kuvelousia cf. *K. kulkii* (Fredericks)
Neophricodothyris sp.
Neospirifer sp.
Stenocisma cf. *S. kochi* (Dunbar) of Harker
Thamnosia arctica (Whitfield)
Waagenoconcha sp.
Yakovlevia duplex (Wiman)

Comments and age: This fauna is probably Roadian and equivalent to those of the Assistance Formation.

Vicinity of Section D, GSC loc. C-82555, 149 m above base of formation

Arctitreta sp.
Cleiothyridina royssiana (Keyserling)
Cleiothyridina cf. *C. subexpansa* (Waagen) of Harker
Kochiproductus sp.
Linoproductus sp.
Neospirifer striato-paradoxus Toula
Spiriferella cf. *S. ordinaria* (Einor)
Spiriferella rajah (Salter)
Stenocisma cf. *S. kochi* Dunbar of Harker
Thamnosia arctica (Whitfield)
Waagenoconcha irginae (Stuckenberg)

Comments and age: This fauna is probably Roadian. The species of *Spiriferella* are unusual and more common to the Yukon. There, they occur in the Tahkandit Formation (Roadian part).

Trold Fiord Formation, Vicinity of Section D, GSC loc. C-82567, 51 m above base of formation

Kuvelousia sphiva Waterhouse

Age: Late Permian, Wordian

Z. Liao, 1983

Nansen Formation, Section G, Unit 1, GSC loc. C-83322, talus at base of formation

Gigantoproductus edelburgensis (Phillips)
G. giganteus (Martin)
G. sp.
Phricodothyris sp.

Comments: The presence of *Gigantoproductus edelburgensis* and *G. giganteus* provide a firm age date (late Viséan–early Namurian), and indicate correlation with Ural, Moscow basin or Russian platform faunas.

E.W. Bamber, 1981

Nansen Formation, Section G, Unit 16, GSC loc. C-83334, 87.5 m above base of formation

Chaetetes sp.

Comments and age: *Chaetetes* ranges from Ordovician to Permian in age, but within the upper Paleozoic of Ellesmere Island it is most common in the Upper Carboniferous.

B.L. Mamet, 1985

Nansen Formation, Section G, Unit 25, GSC loc. C-83339, 232 m above base of formation, chertified former fossil bioclast packstone

Echinoderms, algae, sponges
Ammovertella sp.
Apterrinellids
Bradyina of the group *B. magna*
Calcitornella sp.
Calcivertella sp.
Climacammina sp.
Endothyra sp.
Insolenthitheca sp.
Komia sp.
Pseudoglomospira sp.
Pseudostaffella sp.

Age: Late Carboniferous, Moscovian (not younger than middle Moscovian)

E.W. Bamber, 1981

Nansen Formation, Section G, Unit 25, GSC loc. C-83340, 237 m above base of formation

Chaetetes sp.

Comments: as for C-83334 above

C.A. Ross, 1983

Nansen Formation, Section G, Unit 36, GSC loc. C-83345, 408.5 m above base of formation

?*Fusulinella* sp. (based on shape)

Age: Likely is late Moscovian, Late Carboniferous; recrystallized, ghosts of fusulinids

Hare Fiord Formation, Field Station 28, GSC loc. C-83359, Locality and stratigraphic position as for C-69969

Profusulinella spp.
Bradyina sp.
Ozawainella sp.
Tetrataxis sp.

Age: Late Carboniferous, middle Moscovian

Section F1, Unit 44, GSC loc. C-83369, base of member, 138 m above base of formation

Pseudostaffella ettrainensis Ross
Fusulinella aff. *F. pulchra* Rauser-Chernousova
Tetrataxis sp.
Millerella sp.
aggregation of *Endothanopsis* sp.

Age: Late Carboniferous, Moscovian (probably Podolian)

B.L. Mamet, 1980

Belcher Channel Formation, Section I, Unit 1, GSC loc. C-83452, 325 m below top of formation

Apterrinellids
Calcivertella sp.
Calcitornella sp.
Climacammina sp.
Cuneiphycus sp.
Globivalvulina sp.
Epimastopora sp.
Nodosaria sp.
Tetrataxis sp.
Tuberitina sp.

Age: Early Permian

C.A. Ross, 1983

Belcher Channel Formation, Section I, Unit 9, GSC loc. C-83463, 193 m below top of formation

Triticites? or *Daifina*? sp.
Schwagerina? sp. (small)
Pseudofusulinella sp.

Age: Early Permian, probably Asselian

Section I, Unit 9, GSC loc. C-83464, 173 m below top of formation

Schwagerina cf. *S. emaciata* (Beede)
Schubertella sp.
Bradyina sp. (very large)

Age: Early Permian, probably early Asselian

Z. Liao, 1983

Assistance Formation, Section I, Unit 14, GSC loc. C-83473, 187 m above base of formation

Yakovlevia duplex (Wiman)
Liosotella pseudohorrida (Wiman)
Thamnosia proxima sp. nov.
Stenoscisma cf. *spitsbergiana* (Stepanov)
Cleiothyridina kotlukovi Stepanov
Spiriferella sp.
?*Metriolepis* sp.

Comments: as for C-99547

Section O, Unit 33, GSC loc. C-99547, 45 m above base of formation

Horridonia granulifera (Toula)
H. cf. *scoresbyensis* Dunbar
Neospirifer fasciger (Kerserling)
Spiriferella saranae (Verneuil)

Comments: (C-83473 and C-99547) In the complex of genera and species, the brachiopods of these two localities are essentially similar. This fauna correlates with the faunas of the upper Assistance Formation or lower Trold Fiord Formation.

Degerböls Formation, Field Station 53, GSC loc. C-99579, stratigraphic position unknown

Kuvelousia weyprechti (Toula)
K. sphiva Waterhouse
Horridonia cf. *rudis* Dunbar
Derbyia sp.
Neospirifer striato-paradoxus (Toula)

Comments: These brachiopods seem most similar to the Trold Fiord fauna of central Ellesmere Island. Abundant *Kuvelousia weyprechti* and *K. sphiva* indicate a younger age and a closer relationship to the Brachiopod Chert of Svalbard and the limestone unit of the Tahkandit Limestone of east-central Alaska.

A.C. Higgins, 1986

Emma Fiord Formation, Section B, Unit 9, GSC loc. C-99616, talus, less than 10 m above top of section

Paragnathodus commutatus
Vogelgnathus campbelli
gen. nov., sp. nov.

Comments: *Paragnathodus commutatus*'' has its lowest recorded appearance at the base of the Viséan in the type section of the Viséan in Belgium, but in North America it has not been recorded below the upper part of the Valmeyeran and is most common in the Chester, which would place its lowest appearance in the middle part of the Viséan in North America. Its highest occurrence in both North America and Europe is late Mississippian.

Vogelgnathus campbelli is known only from the Chester Series of the Mississippi Valley, and from the late Viséan-early Namurian of the European sections.

The age of the sample is therefore within the Chester Stage, equivalent to late Viséan–early Namurian in European terminology.

APPENDIX 4

MINERALOGICAL ANALYSES

A. Sedimentary rocks

GSC loc. no.	Locality	Lithology	IM	CK	Q	F	D	C	GA	Remarks
	Okse Bay Formation ***Lower member***									
C-45282	Section A, Unit 17	shale	2	2	92	tr		4		
C-45291	Section A, Unit 41	shale	4	2	94					
C-45298	Section A, Unit 52	coarse grained sandstone		tr	100					
C-45299	Section A, Unit 53	medium grained sandstone			100					fining-upward cycle
C-45300	Section A, Unit 54	fine grained sandstone		2	98					
C-45301	Section A, Unit 55	very fine grained sandstone	tr	2	97	1				
C-45303	Section A, Unit 61	conglomerate		1	99					
	Upper member									
C-45312	Section A, Unit 93	coarse grained sandstone		1	99					
C-45313	Section A, Unit 94	siltstone	3	5	92					
	Emma Fiord Formation Conglomerate lithofacies									
C-69917	Field Station 21	conglomerate		22	59				1	mostly kaolinite, lepidocrocite = 1%, goethite = 17%
C-69918	Field Station 21	medium grained sandstone		7	80				2	goethite = 7%, (?)hematite = 4%
C-83451	Field Station 46	coarse grained sandstone	2	2	80				2	pyrophillite = 13%, (?)rhodesite = 1%
	Siltstone lithofacies									
C-70142	Section C, Unit 1	fine grained sandstone	12	15	44	29 (albite)				mostly mica and dolomite
C-70148	Section C, Unit 6	siltstone	22	30	34	14 (albite)				traces of hematite and pyrite
C-70155	Section C, Unit 16	siltstone	1	1	23	2	49	24		trace of pyrite
C-70170	Field Station 38	siltstone	4	10	66	5		14		(?)rhodesite = 1%
	Borup Fiord Formation Conglomerate-sandstone lithofacies									
C-45333	Section E3, Unit 11	medium grained sandstone	1		99					
C-45334	Section E3, Unit 15	medium grained sandstone	1	1	97					hematite = 1%

GSC loc. no.	Locality	Lithology	IM	CK	Q	F	D	C	GA	Remarks
C-45368	Section E3, Unit 58	medium grained sandstone	2	1	96		1			
C-45369	Section E3, Unit 59	fine grained sandstone	3	5	88				3	hematite = 1% fining-upward cycle
C-45372	Section E3, Unit 60	shale	10		87					hematite = 3%
C-45375	Section E3, Unit 102	fine grained sandstone	11		82	2	4			hematite = 1%, mostly mica
	Siltstone-shale lithofacies									
C-69933	Field Station 23	fine grained sandstone	3	29	51	6		11		probably mostly kaolinite
C-69934	Field Station 23	silty shale	3	13	59	2	2	21		hematite = tr
C-69939	Section F3, Unit 15	fine grained sandstone	4	5	28	51	6	6		
C-70197	Section L2, Unit 5	siltstone	13	16	27	7	14	18		hematite = 5%, mostly clay minerals
C-70306	Section L2, Unit 12	shale	20	42	11	4	9	13		(?)sphalerite = 1%
	Otto Fiord Formation Sandstone-shale lithofacies									
C-69950	Section F2, Unit 2	siltstone	tr	7	71			10	12	
C-69953	Section F2, Unit 7	fine grained sandstone	3	7	82			7		(?)rhodesite = 1%
C-69960	Section F2, Unit 48	shale	2	16	23	1			56	(?)magnetite = 2%
C-69962	Section F2, Unit 65	dolomite	2		18	tr	75		5	
C-83433	Section L1, Unit 1	shale	21	24	16	11	7	16	5	
C-83434	Section L1, Unit 1	medium grained sandstone	17	17	42	12	2	10		mostly kaolinite
	Hare Fiord Formation									
C-83360	Section F1, Unit 22	fine grained sandstone	10	15	60	15 (albite)				mostly mica and chlorite
	Assistance Formation ***Upper member***									
C-69896	Section D, Unit 38	very fine grained sandstone	tr		93			2		(?)rhodesite = 2%, rutile = 3%
C-69898	Section D, Unit 38	very fine grained sandstone	1		80	6		11		(?)rhodesite = 2%
C-83471	Section I, Unit 14	limestone		tr	26	1		73		
C-83474	Section I, Unit 15	very fine grained sandstone	tr	1	48	4	1	45		huntite = 1%
C-83477	Section I, Unit 18	very fine grained sandstone			56			43		(?)rhodesite = 1%

Legend:
IM = Illite/Mica
D = Dolomite
CK = Chlorite/Kaolinite
F = Feldspar
Q = Quartz
C = Calcite
GA = Gypsum/Anhydrite

B. Igneous rocks

Tholeiitic basalt, K = rich series
(Baragar-Lovine classification)

GSC loc. C-70249; Section K, Unit 49

Composition	**Weight (per cent)**
Quartz	10.695
Corundum	8.265
Orthoclase	12.263
Albite	5.370
Anorthite	5.990
Eustatite	27.922
Ferrosilite	7.538
Magnetite	3.374
Ilmenite	3.536
Chromite	0.047
Apatite	0.981
Pyrite	0.065
Calcite	13.953

MAPS
NOT
FILMED

CARTES
OMISES